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VOLUME NO. 5

EXPLANATORY NOTES

FOR

DEPARTMENT OF AGRICULTURE

BUDGET ESTIMATES

FISCAL YEAR

1942

CONTENTS

C O N T E N T S

(Volume 5)

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

(a) GENERAL ADMINISTRATIVE EXPENSES

Appropriation Act, 1941	$166,280
Transferred 1941, to "U. S. Mail and Messenger Service, P. O. Dept. (General Fund)", pursuant to the provisions of the Reorganization Act of 1939 and Reorganization Plan No. IV	- 300
Total available, 1941	165,980
Budget Estimate, 1942	165,980

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
General administration and business service	$165,801	$165,980	$165,980
Unobligated balance	479	- -	- -
Total appropriation	166,280	165,980	165,980

WORK UNDER THIS APPROPRIATION

The funds provided under this appropriation are used for general administrative purposes, which are discussed as follows:

Objective: To determine policies and provide leadership and direction for the Bureau's program as well as to supply administrative service, such as business activities, editorial work, and library facilities.

Problem and Significance: In an organization with so large and broad a subject-matter field as the Bureau of Entomology and Plant Quarantine, it is necessary that policies be determined on a broad basis and that there be adequate overall direction and supervision of the various working programs. It is also necessary that the service units have a sufficient knowledge and appreciation of the work in the various subject-matter Divisions to deal intelligently with the problems encountered in their respective fields. Inadequate planning or executions on any of these administrative and service functions will have a retarding effect on the operations of the Bureau in important subject-matter fields and may even seriously handicap working programs of vital concern to the agricultural interests of the country.

Plan and Progress of Work: The funds provided under this appropriation are used for general administrative purposes comprising the following

functions:

(a) Determination of policies;
(b) General administrative supervision of all departmental and field activities;
(c) Business operations;
(d) The approval and preparation for publication of manuscripts concerned with the scientific, technical, and other activities of the Bureau;
(e) The preparation and distribution of general information of control of insect pests;
(f) The maintaining of a comprehensive library of entomological literature and the preparation of bibliographies on entomological subjects;
(g) The handling of general information relating to Federal quarantines and the preparation of cases on quarantine violations.

The continuation of these activities is essential to the effective and economical administration of the Bureau of Entomology and Plant Quarantine.

SUPPLEMENTAL FUNDS

Direct Allotment

Project	Obligated, 1940	Estimated obligations, 1941
Emergency Relief Appropriation Acts of 1939 and 1940: For administration of emergency work relief projects set forth under the various headings in the following notes and summarized at the end hereof	$203,226	$103,408

(b) FRUIT INSECTS

Appropriation Act, 1941 .... $424,600
Budget Estimate, 1942 424,600

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Investigations on:			
1. Apple and pear insects	$90,236	$90,670	$90,670
2. Peach insects................	51,958	52,869	52,869
3. Grape insects	10,918	10,995	10,995
4. Nut insects	26,080	26,500	26,500
5. Insects attacking dried fruits	15,703	16,002	16,002
6. Citrus and other subtropical fruit insects	40,620	41,020	41,020
7. Fruit flies which are potential pests in continental United States	73,431	75,411	75,411
8. The insecticidal value of oils	5,035	5,120	5,120
9. Japanese and Asiatic beetles	109,577	106,013	106,013
Unobligated balance	5,042	- -	- -
Total appropriation	428,600	424,600	424,600

WORK UNDER THIS APPROPRIATION

General: This appropriation provides for investigations for development of control measures for insects affecting fruits, fruit trees, nuts, grapes, and those small fruits which have their seeds internally, such as blueberries and cranberries. These also include investigations on the Japanese and Asiatic beetles and fruit flies--such as the Mediterranean fruit fly and the Mexican fruit fly. The studies on insects other than fruit flies native to other countries are directed by the Division of Fruit Insect Investigations which is headquartered in Washington. Field laboratories at which investigations are carried on and where growers may obtain information as to control of pests are maintained in the principal fruit-growing regions of the country. The investigations on fruit flies native to other countries are directed by the Division of Fruit Fly Investigations with headquarters in Mexico City, Mexico. Field laboratories for these studies are maintained in Mexico, Hawaii, Puerto Rico, and in the Canal Zone.

The various activities are described in the following paragraphs:

Project 1. Investigations on Apple and Pear Insects:

Objective: To develop more effective and more economical methods of controlling the numerous insects that attack the apple and pear, in order to increase the net return to the farmer by reducing production costs or by increasing the proportion of high quality fruit produced.

The Problems and Their Significance: The apple and pear rank high among the fruit crops of the country. The average farm value of the apple crop for the period 1934-38 was approximately $120,000,000, and that for pears for the same period about $18,000,000.

Both the apple and pear are attacked by a long list of insect pests. The most important of these is the codling moth, which occurs in all apple-and pear-producing regions, and which is extremely difficult to control in the warmer and in the more arid sections, where complete control cannot be obtained in spite of the making of 6 to 10 successive applications of spray during the season. The standard insecticide for the control of this insect is lead arsenate, which, in addition to not being fully effective under conditions of severe infestation, sometimes causes serious damage to trees, results in undue accumulation of arsenic in orchard soils and leaves a residue on the fruit that must be removed by washing, which is very difficult in the case of heavy residue loads. It has been estimated that the codling moth causes an annual loss of at least $13,500,000, in spite the expenditure of several million dollars for control. Figures prepared by growers have shown that the cost of controlling this insect amounts in severe infestations to 40 percent of the total cost of production. Major attention is therefore being given to this insect, although several others are included in the present program under this project.

The most recent development has been the occurrence of destructive outbreaks of Comstock's mealybug in a number of eastern orchards from North Carolina to Ohio and New York State. The injury caused by this introduced insect has been so severe during the last few seasons in a few localities that the crop was entirely unmarketable in the more heavily infested parts of certain orchards. The insect has appeared in an increasing number of orchards for several years, and because of its demonstration of a capacity for extreme destructiveness, the growers have become much alarmed. Thus far no adequate control measures have been found for this mealybug. The chief damage caused by this insect results from its profuse production of honeydew, which covers the twigs, leaves and fruit. This honeydew supports the growth of a sooty mold or fungus; when the insect is abundant, the fruit is very much stunted and colors poorly and irregularly. The sooty mold is very difficult to remove by the washing process, and its presence lowers the grade of the fruit or renders it totally unmarketable, except for by-products. The waxy covering of the body of the insect and of the egg masses prevents the ordinary sprays from coming into close enough contact to give satisfactory control. Also, the insect's reproductive capacity is so great that nearly perfect kill of

the eggs during the dormant period is necessary if the control obtained is to carry through to the destructive third generation the following season. A laboratory was established at Charlottesville, Va. in the spring of 1940. At that point is being carried on a study of the biology of the insect under conditions existing in eastern apple orchards, with special reference to natural enemies that may already be present, and the influence of various orchard practices, including spraying, on the abundance of the insect, its parasites and predators. In order to develop biological control to its maximum extent, parasites of the mealybug are being liberated in representative orchards in all parts of the country where infestations occur, and studies are being made of these parasites to determine their adaptability to the conditions under which they are placed and the effect of various spray programs on their establishment and subsequent abundance. When the problem was first given consideration by the Bureau in 1938, arrangements were made to bring in from Japan certain parasites which were known to be of importance in the natural control of that insect in the Orient. A stock of parasites was received in the fall of 1939 and liberations are being made at a number of representative points during 1940.

Attention is being given to the pear thrips on pears and prunes in the Northwest, where standard spray measures are difficult to apply because of seasonal conditions, and to the apple maggot in the northeastern part of the country. The latter insect had previously been controlled by the program followed for the codling moth, but this now involves difficulties with spray residue. Other insect problems on apple and pear are investigated as occasion demands.

Plan and Progress of Work: Because of the wide variety of conditions under which the codling moth or apple worm affects the production of apples and pears, laboratories are maintained at several representative points, including Beltsville, Md., Poughkeepsie and Geneva, N. Y., Kearneysville, W. Va., Vincennes, Ind., St. Joseph, Mo., and Yakima, Wash.

The greatest emphasis is being placed on the development of an insecticide that will be more effective and less objectionable than lead arsenate. Materials made available by the Division of Insecticide Investigations or from other sources are given preliminary testing at Beltsville, Md., and at Vincennes, Ind. During 1939, approximately 250 new compounds were tested in this manner. The few materials showing sufficient promise are then taken into field testing at several laboratories, in order that information may be available on their effectiveness and behavior under a variety of climatic conditions. At Vincennes, Ind., the work takes the form of a combination of laboratory and field testing. The fruit is sprayed on the trees in the usual manner and exposed to normal weathering. At intervals, samples are taken to the laboratory and artificially infested with a known number of newly hatched codling moth larvae. In this work in 1939 approximately 245,000 newly hatched codling moth larvae were used in tests involving nearly 50 different spray formulas or schedules. At the other laboratories, the field tests included about 500 replicate plots of one to four trees each, treated with the various mixtures under test.

It is proving to be a difficult task to replace lead arsenate, but limited progress in this direction is being made. One material developed by the Bureau - phenothiazine - has shown a high degree of toxicity to the codling moth and in some field tests has given outstanding control. In many other tests, however, it has appeared to be comparatively ineffective, and the main task at the present time is to determine the reasons for its failure under some conditions and to develop means of overcoming this difficulty. The so-called fixed nicotines have been given a great deal of attention by the State and Federal workers, and a tank-mix nicotine bentonite formula developed by the Vincennes, Ind., laboratory has proved to be more effective in southern Indiana orchards than the standard lead arsenate treatment and has been successfully used by growers on 1000 acres of orchard. Unfortunately, this material is not compatible with standard fungicides which must be used for disease control, and much further work in cooperation with the plant pathologists is needed before a mixture of this kind can come into general use.

A great deal of attention is also being devoted to methods of control other than spraying. Orchard sanitation, which includes the cleanup of trash from underneath the trees, the scraping of loose bark from the trunks and larger branches and the use of chemically treated bands, is a group of measures which are of great value in holding the codling moth population at a low level.

A number of bait materials, chiefly aromatic chemicals in combination with fermenting sugar solutions, have been found very attractive to adult codling moths and large numbers of moths have been caught by their use. It is believed that these practices employed over sufficient area would be of great value in reducing codling moth populations. It has not been possible, however, to demonstrate this value because of the fact that moths have come to the baits from considerable distances outside of the baited areas, thus destroying any comparisons that might otherwise have existed. For instance, in a 10-acre block at Yakima, Wash.,144,000 moths were captured in one season's operations, yet there was no difference in the proportion of wormy fruit between the baited block and nearby unbaited trees. In this case the benefit from the practice was apparently distributed over a wide area, and no measure of it was available. Further work is being done with bait materials, and it is hoped ultimately to be able to carry on a practical experiment on a large enough scale or in a sufficiently well isolated group of orchards to permit definite conclusions.

Studies are also being made of light traps, certain types of which capture large numbers of codling moths. Definite reductions in infestation from the use of light traps have been demonstrated. At the present time the cost of installation is too high to warrant the practical use of light traps but the work with them is giving valuable information on the behavior and habits of the insect.

In the work with the pear thrips in pears and prunes special attention is being given to the biology of the insect as a basis for the better timing of the spray applications. When properly put on, standard

sprays have been found quite effective but frequent rains and soft ground have interfered. Experimental work is also being carried on with dust materials which can be applied more readily on the soft ground.

In the work with Comstock's mealybug in eastern apple orchards, emphasis is being placed on control by natural enemies, since the ordinary insecticides do not seem to be effective. Two species of parasites that are valuable control agents in Japan have been received from the Division of Foreign Parasite Introduction, and are being colonized in a number of representative orchards where mealybug infestations are severe. In addition, one other parasite which is abundant in Virginia is being colonized in Ohio, where it appears to have been absent thus far. Certain ladybird beetles that feed on mealybugs have been introduced from California for experimental liberation.

Field experiments with various lead arsenate substitutes for apple maggot control are being carried on in the Hudson River Valley. Experiments with methyl bromide fumigation against the pear psylla are also being carried on in support of the large-scale suppression or eradication project that is under way in the Pacific Northwest. The insect material for these experiments is collected by the Poughkeepsie, N. Y., laboratory and the fumigation experiments are carried on at Moorestown, N. J., where facilities for such work are available.

Project 2 . <u>Peach Insect Investigations</u>:

<u>Objective</u>: To develop better methods of controlling important insects attacking the peach, to develop the use of control by parasites to its fullest possible extent, and to determine the insect or insects that may be responsible for the transmission of certain virus diseases of the peach.

<u>Problem</u>: The peach is attacked by a large number of different pests. The most important of these are perhaps the plum curculio, which infests peach and many other fruits throughout the United States east of the Rocky Mountains, and the oriental fruit moth, which reached this country about thirty years ago and which is extremely destructive in some localities. The work under this financial project also includes a study of various insects to determine which, if any, are responsible for the transmission of the phony peach disease and peach mosaic, two destructive virus diseases of the peach for which the Bureau is carrying on control programs.

<u>Significance</u>: The peach crop ranks well up among the fruit crops of the United States, the average annual farm value for the period 1934-38 being more than $45,000,000. This crop is subject to serious losses from a number of pests.

The oriental fruit moth, a comparatively recent introduction from the Orient, usually works in the shoots of the tree during the spring and early summer, turning its attention to the fruit as the shoots begin to harden and the fruit approaches maturity. No definite estimate of the

losses caused by this insect is available but in many cases 10 to 30 percent or more of the harvested peaches are affected. Because of the peculiar feeding habits of this insect, no satisfactory method of control by insecticides has been developed.

The peach tree borers work in the roots, trunk, and larger branches of the tree, the most important species occurring chiefly in the trunk at the ground line. When many borers are present in the tree it may become completely girdled and die. With less severe infestations the trees are weakened, and are rendered especially subject to attack by disease or barkbeetles.

The plum curculio has been estimated to cause annual losses of at least 15 percent of the peach crop in the area in which it occurs, which means a total annual average loss of $4,000,000, plus a cost of at least $1,000,000 for control measures. The standard method of control - spraying with lead arsenate - has given reasonably satisfactory results, but the use of this material is limited by the fact that the peach tree is extremely sensitive to injury by arsenicals, and the number of applications that can safely be made is very restricted. The development of materials or methods of control that do not involve the use of lead arsenate is therefore an urgent need of the peach industry.

The peach is subject to several destructive virus diseases. Two of these - the phony peach and peach mosaic - occur in limited portions of the country and this Bureau is carrying on intensive cooperative programs to control and prevent the further spread of these diseases. Many virus diseases are transmitted only by insects and it is believed that this is true of the phony peach and peach mosaic, although no insects have as yet been incriminated. It is essential to the success of the suppression programs that information be obtained on the insects responsible for the spread of these virus diseases. As a first step in the investigation of the part played by insects in the transmission of these diseases, a careful survey was undertaken of peach orchards to determine what insects were present. It was expected that an accumulation of records of insect populations in relation to the rate of natural spread would point to the insect or insects most likely to be causing the transmission of the phony peach disease and the peach mosaic. These surveys have indicated a number of insects that may be suspected of transmitting the viruses that cause these diseases, and this has made necessary the establishment of fixed laboratories for carrying on definite transmission experiments.

Plan and Progress of Work: In view of the fact that the oriental fruit moth has not been found controllable by the use of insecticides, the efforts of this Bureau have been in recent years devoted to methods of control other than spraying. Except for incidental attention to the use of baits, practically all of the funds available for work on the oriental fruit moth are being devoted to work with insect parasites that prey upon the fruit moth, headquarters for the work being at Moorestown, N. J. The most effective of these parasites, known technically as *Macrocentrus ancylivorus*, was first found in the eastern United States, and has been

recolonized in practically all of the peach-growing sections east of the Rocky Mountains where the oriental fruit moth is an important factor. In many of these localities, the introduction of this parasite has been followed by its establishment, and marked reductions in the level of fruit moth population. In some localities and in some seasons, however, the efforts of this and other parasites are not adequate to give control. Experiments carried on the last two years have shown that the liberation of comparatively small numbers of parasites in the orchard early in the season is usually followed by a sufficient build-up of parasites to give a marked degree of control of the later peach-infesting generations of the fruit moth the same season. Present efforts are being devoted to the development of more economical methods of producing the parasite for liberation for direct control. A long list of parasite species were introduced from the Orient and elsewhere a number of years ago but for the most part are not known to be established or, if established, have not proved to be of much importance in the control of this pest. Some of these parasites may, however, gradually adapt themselves to local climatic conditions and become of greater importance later on.

In order to develop a method of controlling the plum curculio on peach less objectionable than spraying with lead arsenate, particularly in the South, where a second generation of this insect usually occurs, experiments are being carried on at Fort Valley, Ga., with soil treatments against the larvae and pupae, which spend about a month in the ground between the first and second generations. Favorable indications have been obtained in laboratory experimentation and in preliminary field work. Experiments on a larger scale in the field are now under way.

In the studies of possible vectors of peach virus diseases, it was intended to work first on the phony peach disease and then to take up the problem of peach mosaic. Because of the urgent need that existed, however, both diseases are now being studied. The first step has been to make surveys of the areas in which these diseases are present and spreading, to determine what insects are present. A comparison of these records with those taken in areas in which the diseases are not spreading, or from which they are absent, has given lists of insects suspected of having a part in disease transmission. In the survey work, use has been made of mobile trailer laboratories, which permits the carrying on of detailed studies right in the orchards. In 1939, the trailer laboratory used on the peach mosaic work travelled more than 19,000 miles, and 5,000 records of insect occurrence were made. The work with phony peach that season involved travel of some 12,500 miles.

A great many of the insects pointed to by the surveys as possibly being responsible for mosaic spread have been used in transmission experiments. At San Bernardino, Calif., 622 mosaic vector tests were made during 1939, involving more than 42 species of insects. At Brownwood, Texas, 410 mosaic transmission tests were completed during the year. At East Chattanooga, Tenn., a start has been made in tests to determine the ability of various suspects to transmit the phony peach disease. Technique is being worked out for the handling of underground insects (infection by phony peach disease probably occurs through the roots). The transmission experiments have not yet resulted in the incrimination of any insect, but a long

list of suspects remains to be tested, and it is hoped that this work can be intensified.

Project 3. Grape Insect Investigations:

Objective: To develop more effective and economical methods of controlling the various insects attacking grape, especially the grape berry moth and grape leafhopper.

The Problems and their Significance: The grape crop of the United States brought the growers an average annual return of more than $42,000,000 for the 5-year period 1934-38 inclusive. Although the greater part of the production is centered in California, grapes are grown in every State of the Union, and the production of this crop is an important item in the Great Lakes region, where the work under this financial project is carried on.

The grape berry moth is a limiting factor in grape production in many eastern and Great Lakes States. It is of special importance in the latter area, where in the absence of control measures it may destroy a high percentage of the crop, reducing it to the point where it has comparatively little value. This insect was formerly well controlled by two to four applications of lead arsenate during the growing season. Unfortunately a program of this kind results in excessive poisonous residues on grapes when harvested, and it has been necessary to reduce to a minimum the use of arsenicals. The quantity that can be applied without causing excessive residues is inadequate for control of berry moth infestations. This has left the growers of grapes, especially in the Great Lakes region, in a difficult situation, which has been intensified by the economic difficulties in which eastern grape growers have found themselves in recent years. The development of effective and inexpensive means of control not involving a spray residue problem is one of their most urgent needs.

With a curtailment in the extent to which arsenicals are used it is expected that many other insects attacking the grape, such as the grape rootworm, which were formerly controlled incidentally by the berry moth sprays, will increase to destructive numbers.

Plan and Progress of Work: A field laboratory is maintained at Sandusky, Ohio, in a locality representative of the Great Lakes grape-growing areas. Laboratory and field experiments are being carried on with a number of materials which might be substituted for lead arsenate. Most of the compounds tested are those that are under experimentation for the control of the codling moth on apple and pear. Nicotine bentonite has given very effective control of the berry moth, but leaves a conspicuous visible residue which, though nonpoisonous, is objectionable on table grapes and might cause some difficulty with juice or wine grapes. Phenothiazine has given a very high degree of control but this material at the present time is too expensive for use by practical growers because of the fact that the margin of profit in grape production is very small or has disappeared altogether. Several other possible new insecticides, chiefly organic ma-

terials developed by the Division of Insecticide Investigations, have been given limited testing and are being investigated further.

Project 4. Nut Insect Investigations:

Objective: To develop new methods, or to improve present methods for the control of the numerous insects that attack nuts, particularly the pecan and filbert.

The Problems and their Significance: The pecan is one of the most important of the nation's nut crops. In the period 1934-38, the average value of this crop was about $5,500,000. Although this amount is not great, compared with that of some of the staple crops, the returns from pecan trees constitute an important addition to the cash income of many southern families, as well as adding variety to their diet.

Originally growing along the water courses in the lower Mississippi Valley and certain of the river valleys in Texas, the pecan has been planted more or less throughout the southern part of the United States. Among the many production problems encountered by the commercial growers of pecans, that of insect control is especially important, and in some cases the limiting factor in profitable pecan production. In the portions of the United States where the pecan originally grew it is attacked by a large number of different insect pests, which reduce very materially the yield. As named varieties of pecan have been propagated and grown under orchard conditions, and as pecan orchards have been planted in many parts of the United States in which the tree did not originally grow, most of these pests have followed and some of them have become even more serious than they were under natural conditions.

In Washington and Oregon there has been an extensive planting of the filbert nut, which originated in Europe. Production has increased from 60 tons in 1927 to 2230 tons in 1937 and further increase is expected. Until recent years, practically all of the filberts consumed in the country were imported and until the present war interfered, the United States was still importing more filberts than it produced. A few years ago the growers of filberts began to experience difficulty with certain insect pests, particularly the filbert worm, which transferred its attention to the cultivated crop from native hazel nuts and acorns. These insects constitute a threat against the further growth of a profitable industry and the development of effective control measures is needed.

Plan and Progress of Work: The hickory shuckworm is under investigation as a pest of pecan at Albany, Georgia. The problem of controlling this insect, for which no adequate method is now available, is being attacked from two angles - control by insecticides and control by cultural methods. Of the numerous insecticide materials already tested most of them have appeared to have little or no value, largely because of the peculiar feeding habits of the insect. The work is carried on in the orchard in replicated plots, and the trees are sprayed with a heavy duty power sprayer. The use of cultural methods with the idea of controlling the insect in the

pecan shucks in which the winter is passed has likewise thus far proved ineffective, but further experimental work with other types of orchard equipment is planned. The important parasite (Macrocentrus ancylivorus) of the closely related oriental fruit moth has been introduced into Albany, Ga. area in the hope that it would adapt itself to the shuckworm and become an important factor in its natural control.

Of the two most important casebearers, the leaf casebearer is rather readily controlled by a single midsummer spraying with an arsenical. This prevents or reduces to a minimum the destructive infestation in the shoots the following spring. The nut casebearer is more difficult to control, although good results have been obtained by the Brownwood, Tex. laboratory by spraying with lead arsenate or with a mixture of nicotine sulfate and white oil emulsion. The latter method has also been found effective under conditions existing in the southeastern United States, where the arsenicals are likely to cause serious foliage injury. The nicotine-oil mixture, unfortunately is rather expensive for use under present economic conditions and efforts are being made to develop less costly sprays. At Monticello, Fla., laboratory experiments are under way with materials that can be applied during the dormant season when the insects are near the tips of the twigs in their winter shelters.

An investigation of the borers that injure new grafts in top-worked trees has been practically completed. The use of a newer type of grafting wax developed by the Bureau of Plant Industry has been found to exclude the borers satisfactorily. As occasion requires, other insects attacking pecan are given attention.

The investigations of insects affecting filbert nuts have been located at Eugene, Oreg. Thus far the work has dealt chiefly with the filbert worm, and has taken the form of surveys and studies of the biology and host plant relations of this insect, which appears to have transferred from its native food plants to the recently introduced filbert. At least a dozen species of parasites of the filbert worm have been reared and identified; some of these appear to be very important in the natural control of this insect.

Project 5. Dried Fruit Insect Investigations:

Objective: To develop improved methods for the control of insects attacking dried fruits, in order to increase the quality of the pack which reaches the consumer, and to increase the net returns to the grower and packer.

Problem: Drying and dried fruits are subject to attack by insects from the time when they are growing on the tree or vine to the time when they reach the consumer. Some of the most important of these insect pests multiply indefinitely in fruits in storage; a few are primarily field or drying yard insects that do not thrive in storage and gradually tend to disappear after the product has moved to the warehouse. California-grown figs are subject to serious losses by spoilage in the field, caused by various micro organisms. This sometimes causes a loss of 30 to 50 percent of the crop, and it

is difficult to separate good figs from the bad. These diseases are disseminated largely by insects which visit contaminated and uncontaminated figs in succession.

Significance: The production of dried fruits is an agricultural industry of major importance, and the tonnage has steadily increased since 1919. For the 5-year period 1933-34 to 1937-38, the average production was 536,000 tons annually. More than three-fourths of this consisted of raisins and prunes. If uncontrolled, the insects attacking dried fruits render the product unattractive to the consumer and often cause the pack to become valuless. Great improvement has been made in the quality of dried fruits reaching the market in recent years but much work remains to be done before most of the losses from this source can be eliminated.

Plan and progress of work: The Bureau's work on insects affecting dried fruits is carried on at Fresno, Calif. Much of this effort has been to prevent infestation at the source in preference to dealing with it later, after the products have become severely infested and more or less damaged. The initial infestation by the raisin moth, for example, takes place after the fruit is partially dried and is stored on the ranch in stacked trays or boxes. The exclusion of the raisin moth from the pack at this point has been accomplished by covering the stacks with a cloth of the type used in shading tobacco. Cooperative demonstrations carried on in 1937 gave a reduction in infestation from 45 to 9 percent, and this figure included several instances in which the cloth was known to have been used in an ineffective manner. For dealing with raisins that have become infested with the raisin moth, the Fresno, Calif. laboratory of the Bureau has developed a sifting and shaking device which removes practically all of the insects present. Devices of this kind are used by a number of growers in the Fresno region.

Infestation in warehouses is usually dealt with by fumigation, and a number of fumigants are now in practical use. At the present time the Fresno laboratory is investigating the possibility of the use of lower temperatures for insect control, taking advantage of the fact that insect development is practically at a standstill at temperatures below 40° F. and that long continued exposures to low temperatures cause high mortaility among the insects. Experiments carried on the last two or three years have involved the use of at least 300 lots of insects, and have permitted the establishment of tentative temperature time conbinations that should rid dried fruits of all living insects. Further details must be worked out, however, before definite conclusions can be drawn.

Extensive studies are being made by the Fresno laboratory of the habits and biology of insects that are found in dried fruit, the information thus obtained to serve as a basis for the development of control measures. One important development of a few years ago was the finding that the raisin moth carried over the spring months in many localities in mulberries, which fruit very early in the season. A more recent finding has been that the sawtoothed grain beetle, one of the major pests of fruits in storage, does not fly to any extent.

Project 6. Investigations on Citrus and Other Subtropical Fruit Insects:

Objective: To improve methods available for the control of insects affecting citrus and other subtropical fruits in order that a better quality product may be placed on the market and the net return to the grower increased.

The Problems and their Significance: Citrus fruits constitute a major item in American agriculture ranking next to apples among the fruits. The average annual value of the citrus crop to the grower for the period 1934-38 has been estimated as more than $90,000,000. Other tropical fruits, such as the avocado, mango, and papaya, are produced on a smaller scale where climatic conditions permit.

A large number of insect pests attack practically all tropical and subtropical fruits. Many of these are difficult to control and some of them, especially the California red scale and the black scale, appear to have developed in certain sections a resistance to fumigation by hydrocyanic acid gas, which has been one of the standard methods of treatment. The control of these pests constitutes a large item in the cost of production. In California, pest control in citrus orchards frequently costs as much as $50.00 per acre annually, and even with this expenditure thoroughly satisfactory control is not always obtained.

Two chief methods of dealing with the California red scale are available. The first of these is fumigation with hydrocyanic acid gas, which is effective in many situations. In some localities, however, the insect seems to have developed a high degree of resistance to the action of hydrocyanic acid gas, and in such localities no fumigation that is safe from the standpoint of the tree will give adequate control. The second method of dealing with the red scale is by spraying with an emulsion of a highly refined mineral oil. At the proper strength this treatment is fully effective, but often causes severe injury to the tree. A fundamental study of the resistance that now appears to exist and the development of ways of controlling the California red scale are vitally important to the welfare of the industry.

Another California pest which has been under study for some years has been the citrus thrips. The injury caused by this insect takes the form of scarring and stunting of the fruit, reducing severely its grade and market value. On lemons thrips cause considerable injury to foliage, which interferes with the normal functioning of the tree.

In Florida the costs of pest control are not quite so high as those in California, but the grower has to deal with a wide variety of insects. The rust mite is a pest of major importance which causes a russeting of the fruit, reduces its size and throws it into the lower grades. Several species of scale insects, mealybugs, and whiteflies injure the wood, the fruit, or foliage of citrus trees throughout Florida, their control adding materially to the cost of production, and the injury that they cause reducing the quality and volume of the product.

The value of the papaya in the diet is being ralized more and more, and the production of this fruit is on the increase. Papaya growers in Florida are having serious difficulty with the papaya fruit-fly, the larvae of which are found in the seed cavity and in the flesh of the fruit. This is seriously handicapping the development of papaya production, and effective control measures are urgently needed.

An important consideration in the use of insecticides on citrus is the effect of the material on the tree, the fruit or the foliage. Information of this type is especially desirable in connection with the possible use of poison bait sprays for the control of tropical species of fruitflies, if any of them should become established in any of the citrus areas in the continental United States.

Plan and Progress of Work: In the studies of the California red scale it has been found that the results of fumigation in the field are influenced by such a variety of factors that the interpretation of field results is extremely difficult. It has therefore been necessary to take the problem into the laboratory, which is located at Whittier, Calif., and there make an accurate evaluation of each factor separately. Methods have been developed whereby lemons can be artificially infested in the laboratory with scales of known origin and of the same age. With this standardized laboratory procedure much detailed information has been secured which would have been overlooked or confused by other factors in the field. Among the factors which have been evaluated separately may be mentioned the temperature at the time of fumigation, the termperature immediately following fumigation, the relative susceptibility of different strains of scale to treatment with hydrocyanic acid gas, the influence of the stage in which the insect is present, and the influence of various types of concentration curves. This work has led to a much better understanding of the entire problem and the work has now reached the point where field results can be much better interpreted and evaluated. The differences in susceptibility to cyanide fumigation that have been observed under field conditions have been maintained with two strains of the California red scale that have been propagated in the laboratory for at least five years under identical conditions, but completely isolated from each other.

The experiments with the citrus thrips are carried on largely in the field. The work of this Bureau a number of years ago resulted in the development of sulfur dusting for the control of this insect. This treatment has been very satisfactory on oranges but there has been some difficulty in its use on lemons because of the fact that some newly formed fruits, which are especially susceptible to thrips injury, are present on the trees throughout the season. This necessitates applications of dust during the hot portion of the year, which has frequently resulted in severe foliage injury. Experiments are therefore being carried on with a number of different materials and methods of application. During the crop season of 1938-1939, field experiments were carried on in orchards in two localities in southern California; the work included a total of 14 different large-scale field plots. Of several materials tested as possible

substitutes for sulfur; dusts of nicotine bentonite and of one of the thiocyanates gave the most favorable results.

In Florida it has frequently been observed that the use of Bordeaux mixture and certain other sprays on citrus was followed by a rapid buildup of scale insects. For a number of years the explanation of these observations was assumed to be that the copper present in the Bordeaux mixture had an unfavorable effect on the insect-feeding fungi that normally keep the infestation at a low ebb. The recent work of this Bureau's laboratory at St. Lucie, Fla., has shown that the copper has very little to do with this, and that the buildup of the scale results from the presence of a heavy residue, irrespective of whether copper is present or not. This means that the so-called entomogenous fungi actually play very little part in the natural control of scale insects.

Continued work with the citrus rust mite deals largely with various adhesives for use with wettable sulfur in order to reduce the number of applications needed for satisfactory control. Field experiments carried on in late 1939 and early 1940 involved the practical spraying or dusting of plots in the field with nine different combinations. A single application of finely divided wettable sulfur with cottonseed oil or with fish oil gave protection during the period September 1939 to March 1, 1940, whereas with many of the other materials additional applications were necessary to give protection for the same length of time. The mite infestation in one orchard increased very suddenly after the cutting of the annual crop in the orchard, and an investigation is being made into the influence of cover crops on mite abundance.

Project 7. Investigations on Fruit Flies which are Potential Pests in Continental United States:

This project is concerned with investigations on the biology and methods of controlling certain important fruit flies in their native regions in order to provide information which will aid in preventing them from entering the United States and the development of methods for their control if they should become established in the United States. The investigations are headquartered in Mexico City, Mexico; Honolulu, T. H.; Balboa, Canal Zone, and Mayaguez, Puerto Rico.

The following sections discuss the work at each of these locations:

(a) Fruit Fly Investigations in Hawaii:

Objective: Two fruitflies occur in Hawaii. One makes commercial fruit production, with the exception of pineapples and bananas which are not attacked, largely impossible. The other greatly restricts vegetable production. The object of the work is (1) to develop methods of sterilization whereby products possibly carrying infestation may be safely shipped to the mainland and so provide markets for expanded production (2) to develop methods of control which will eliminate large losses on the islands themselves.

Significance: The need for expanding food resources on the islands is a patent need in view of situation already arising and emergencies that may follow.

Plan and Progress of Work: The research is carried on in a laboratory in Honolulu and in the field. The vaporheat method of sterilization has been perfected for Hawaiian conditions and commercial shipments to the mainland are now in progress. A fumigation method permitting such shipment has just been completed and approved. A control for vegetable production is nearing completion and experimental results are highly promising.

(b) Fruit Fly Investigations in Mexico:

Objective: Several destructive fruitflies occur in Mexico and one of them, Anastrepha ludens, already appears in the United States, occurring in the citrus plantings of Texas in increasing numbers. The objective is to determine the habits of these Mexican fruitflies, their potentialities if they should establish themselves in the United States, and methods for suppressing or controlling them.

Significance: These fruitflies produce heavy losses in Mexico and what might happen in the United States has already been indicated in Texas by infestations there.

Plan and Progress of Work: A laboratory is maintained in Mexico City and a field study location in Tamaulipas. The laboratory was started when ludens was first found to have invaded the citrus plantings of Texas. Since infestation in Texas would prevent crop movement into other states research was devoted to the perfection of methods for treating Texas fruit in order to guarantee it safe for movement anywhere. Two methods have been perfected and the vapor-heat treatment is now used by Texas packers each year to ship a large tonnage of fruit that would otherwise be embargoed. The packers report that the method not only guarantees the fruit safe as far as fruitfly is concerned but reduce the decay found in untreated fruit. Research on poisons used in sprays is directed toward a method to protect fruit crops from infestation. An apparatus has been invented, and patented for the people, which permits laboratory duplication of seasons recorded in any place. This allows tests of the climates in United States fruit growing regions to determine how dangerous species would be if they got into those regions. Since it now seems possible that flies may migrate naturally from Mexico into United States points, research has been started on the development of repellent sprays with the idea that American plantings might be treated so moving flies would avoid them.

(c) Fruit Fly Investigations in Puerto Rico:

Objective: Two injurious fruitflies occur in Puerto Rico. The work has been designed to determine the dangers of these species to continental production and to devise methods for treating products that

might be infested.

Significance: The close proximity of the large Florida Industry and other industries where the species might become introduced.

Plan and Progress of Work: When the work was undertaken entomologists believed there was one injurious species attacking several crops. Studies proved that there are two, one of which is found in citrus, etc., and the other in mango and related things. Study of the habits and population movements of the citrus species showed that its populations are built up in tropical things and that its attack on citrus, which is light, is merely incidental to the population drift. That would not occur in the continental area. Therefore this study was wound up and the restrictions against Puerto Rican citrus modified.

Effort was then directed toward the other species which proved to be a primary and serious pest of mangoes and related things. Methods for treating products attacked by this species are under way in order to permit the opening of markets to such products and the expansion of those industries. It is contemplated that this phase of the research will be completed in the near future.

(d) Fruit Fly Investigations in the Canal Zone:

Objective: To evaluate the fruitfly situation in Central America as it may influence Continental United States.

Plan and Progress of Work: Very little was known about the situation in Central America. The work has turned up about 60 species, most of them not known to science and studies are being made on the things they attack. Zetek, who handles this work with some native help, cooperates in many ways with the Canal Authorities. Being also a specialist on mollusks he makes the examinations for marine borer injury in the borer-resistance tests of materials for piling, docks, etc. He makes the examinations for the Bureau in the termite-resistance tests of variously treated woods and is consulted on termite damage by the Army as well as on other points at times.

Project 8. Investigations on Insecticidal Value of Oils:

Objective: To develop further the use of oils as insecticides, with particular reference to the use of added toxicants with the oil.

Problem: Oils are among the most effective contact insecticides for the control of insects with sucking mouth parts, but their use is limited by the injurious effect on the trees or plants that are treated. There are many indications that by the use of added toxicants the proportion of oil used could be somewhat reduced without loss in effectiveness, thus permitting a more extensive use of this effective group of materials.

Significance: A problem in which the increased use of oils or oils with toxicants would be especially helpful is the control of the California

red scale, for which fumigation is very expensive as well as only partially effective against the resistant form. If an effective, safe, and economical combination could be worked out, the growers would benefit greatly by improved control of the scale and reduced cost of production.

Plan and progress of work: The work under this financial project is carried on at Whittier, Calif., where general investigations of the California red scale are under way. Experiments are being carried on in the laboratory and field with various grades of petroleum oil in combination with different toxicants. The most favorable results have been with cube resins combined with highly refined oil, either in the form of an emulsion or of a soluble oil. Laboratory experiments showed increased mortality from 59 percent with oil alone to 97 percent with oil combined with 1 gram of cube extract per 5000 cc. of diluted spray. Practical field applications by commercial operators gave results in line with those obtained in the laboratory. The use of nicotine with oil has also given favorable results. Several mutual solvents are under investigation for use in obtaining mixtures of the cube resins and oils.

Project 9. Investigations on Japanese and Asiatic Beetles:

Objective: To develop better methods of controlling Japanese and Asiatic beetles, and methods whereby the spread of these recently introduced pests to uninfested areas may be prevented or retarded.

Problem: The Japanese beetle, a pest of oriental origin, was first found at Riverton, N. J. in 1916. Since that time it has increased enormously in numbers and has spread to 20 or more states. The area occupied by it in the region of continuous infestation now covers more than 16,000 square miles from Connecticut to Virginia. Isolated infestations have also been found in many other states from Maine to Florida and west to Missouri and Illinois. The adult feeds on a wide variety of fruit and shade trees, ornamental shrubbery, flowers and vegetables. In the grub stage the insect feeds chiefly on the roots of grasses and other plants, when abundant causing serious injury to turf.

Several other closely related beetles of oriental origin reached this country about the same time as the Japanese beetle. These include the Asiatic garden beetle, the oriental beetle and the imported Serica.

Significance: The Japanese beetle has proved to be one of the most destructive pests that has reached this country for many years. No reliable estimates of the total damage caused by it are available. A rather comprehensive survey of Cumberland County, N. J. made during the summer of 1934 under the auspices of the New Jersey Emergency Relief Administration showed actual crop losses of nearly a million dollars in that one county. In addition, there were extensive losses of an intangible nature to flower gardens, ornamental shrubbery and shade trees which could not be expressed in dollars and cents. Because of the insect's abundant occurrence through the thickly populated eastern seaboard area, it has become well known to more people than any other plant-feeding insect pest.

Because of the extreme abundance of the Japanese beetle, its powers of active flight, and its tendency to enter passing vehicles and freight cars, it has spread to a great many new localities. The Department, however, is doing everything possible to retard this spread, and thus to protect the uninfested areas of the United States as long as possible. Much of the research work under this project is intended to furnish information needed in connection with the retardation program. Measures have been developed whereby the individual property owner can protect his own plantings with reasonable success but much further improvement is needed.

Plan and Progress of Work: Most of the research on the Japanese and Asiatic beetles is carried on at Moorestown, N. J. In addition, certain of the studies relating to the outer zone of isolated infestations are carried on from headquarters at Spencer, N. C.

As a basis for all of the work on the insect, studies are made of its biology, food plant preferences, and habits in the various areas which it has occupied.

A number of methods of controlling the adult Japanese beetle are under investigation. Numerous insecticides or repellents have been tested in recent years under laboratory conditions. For instance, during the season of 1939, 280,000 beetles were used in 1404 cage tests of 45 new materials. Of these, only two materials were found to be of any particular value in beetle control, and one of these, unfortunately, was seriously injurious to foliage. Extensive field experiments have been carried on with traps, which catch tremendous numbers of beetles, especially in areas of heavy infestation. The value of traps in practical control is still somewhat debatable, but they are very extensively used to determine the distribution of the beetle in connection with efforts to retard spread. The tests now under way deal chiefly with trap color and with various individual constituents of commercial geraniol, which is used as the attractant.

In dealing with isolated infestations, as well as in controlling grubs in golf courses, park areas and lawns, the most effective method is the use of lead arsenate in the ground. Studies are under way to determine the influence of soil type on the effectiveness of this treatment. From January 1935 to March 1939 some 44,300 pot tests, involving about 221,500 grubs, have been completed. Although for most soils the present treatment appears fully adequate, there are a few soil types in which lead arsenate does not give satisfactory results. A method of biological assay has been worked out whereby determinations are made of the quantity of lead arsenate needed for effective results in soil treatments against the grubs in isolated infestations, from which, if unchecked, the further spread of the beetle would be rapid. During the spring and summer of 1939, 3540 samples of turf were taken from 35 treated areas in 18 cities in 11 states to determine the current effectiveness of treatments that had been applied. This work is being continued in order to point out any need that may exist for additional treatments in such areas.

In connection with the prevention of spread from the older heavily infested areas, many farm products are fumigated before movement. During 1939 and in the winter of 1939-40, a detailed investigation was made of the fumigation with methyl bromide of balled and potted nursery stock for the prevention of the movement of the insect in such shipments. Some 225,000 grubs and 63,600 adult beetles were used in this study, on the basis of which detailed dosage requirements for complete mortality were worked out for a wide range of temperatures.

The apparent reason for the low level of infestation by the Japanese beetle in oriental countries is the presence of various parasites and other natural enemies. The most promising of these parasites were brought to this country a number of years ago. Of these, two species of wasps are the most effective, and these are being recolonized in the areas newly infested by the Japanese beetle, whenever the insect population reaches a sufficiently high level. During May, 1939, 14,813 females of one of these species (the so-called spring Tiphia) were collected and recolonized at 145 points in 6 states from Maryland to Connecticut. The total number of colonies of this species in the field at the end of the 1939 season was 1,272, distributed over 9 states and the District of Columbia. During the late summer of 1939, 3,300 females of another species of parasite (the fall Tiphia) were collected and recolonized in 4 states, bringing the total number of colonies of this species to 709, distributed over 7 states. Thus far the stocks of these parasites for distribution have been collected in the field from established colonies. Work is now under way to develop effective laboratory methods of rearing the parasites in order that they may be available in larger numbers and, it is hoped, at a lower cost.

Perhaps the most promising recent development has been the outstanding reductions in infestation resulting from the presence of a bacterial disease of the grubs in the soil, referred to as the milky disease. Although grubs affected by this disease have been observed for a number of years, it was only a few years ago that it appeared to assume much importance. In one outstanding case observed recently, a reduction in grub population within a six months' period from 38 to 2 per square foot following the natural occurrences of this disease.

The disease has been found chiefly in the older infested areas, and its natural spread seems to lag behind the spread of the beetle. It is believed, however, that artificial introductions will accelerate its dissemination, and may prevent new beetle infestations from reaching as high a point as they have in the past. Since the organism does not develop the spore stage in artificial cultures, it has been necessary to propagate it in the bodies of living grubs. A method has been developed which permits easy handling and storage of the milky disease material in the form of a dry dust. The distribution of these disease organisms is being made in a number of infested Federal parks and reservations, and they will be placed in other representative locations in the infested area. The University of Maryland has started a distribution of these disease organisms, as an important feature of

their Japanese beetle suppression program. This Bureau has furnished them with full information on the methods of producing and handling the bacteria, and is further cooperating by furnishing the use of much of the necessary equipment.

(c) JAPANESE BEETLE CONTROL

Appropriation Act, 1941	$395,000
Second Deficiency Act, 1940 (available in 1941 for control and prevention of spread of the Japanese beetle)	30,000
Total available, 1941	425,000
Budget estimate, 1942	425,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Japanese beetle control operations:			
(a) Supervision of nurseries and greenhouses for Japanese beetle control	$163,751	$187,000	$187,000
(b) Scouting adjacent to nurseries and greenhouses for Japanese beetle control	29,752	30,000	30,000
(c) Trapping to determine distribution of the Japanese beetle	70,276	78,800	78,800
(d) Soil treatment and trapping in isolated areas to aid in preventing spread of the Japanese beetle	28,951	37,200	37,200
(e) Farm products inspection for Japanese beetle control	30,203	22,500	22,500
(f) Vehicular inspection for Japanese beetle control	50,628	51,000	51,000
(g) Transit inspection for Japanese beetle control	6,979	7,000	7,000
(h) Tests of treatment required for Japanese beetle control	11,485	11,500	11,500
Unobligated balance	2,975	- -	- -
Total appropriation	395,000	425,000	425,000

WORK UNDER THIS APPROPRIATION

Objective: This appropriation provides for operations to prevent spread of the Japanese beetle, including inspections to determine spread, the enforcement of quarantine regulations to prevent and retard spread into new localities, and inspection and certification of nursery stock and other materials, the movement of which is regulated under Federal and State quarantines. It also provides for operations carried on in cooperation with the state and local agencies to suppress the beetle (1) in

localities considerable distances from the generally infested area to prevent the development of new centers of spread, and (2) in areas within infested sections where the state and local agencies actively engage in an effort to control the beetle and thus retard the build-up of heavy infestations in other parts of the state.

The Problem and its Significance: The Japanese beetle is highly destructive to a wide variety of fruits, vegetables and ornamental plants. Unfortunately it occurs in the largest nursery sections of the United States, and also in large fruit and truck producing areas. The control of this insect therefore presents the dual problem of suppressing it and preventing its establishment in uninfested areas, and at the same time avoiding, as far as possible, serious disruption of the shipment of plants and plant products from regulated areas, to the disadvantage of both producers and consumers.

The values represented by investments in nurseries and farms in the regulated areas, and the economics, as well as the quarantine aspects of protecting areas as yet uninfested, make this a problem of major importance.

Plan of Work: This project includes a number of different, but coordinate, activities, which are discussed in the following paragraphs.

Nursery products produced in the infested area are shipped to every state in the United States. To prevent them from carrying the beetle to uninfested sections all those moving from the quarantined area must be handled or treated in a manner to eliminate risk of spreading of infestation. Products produced or handled as required by quarantine regulations and after prescribed inspection are certified and may move freely and without risk of carrying the pest into new sections. The requirements provided as a basis of certification vary with the class of nursery stock and the degree of infestation in or adjacent to the nursery or greenhouse in which it is produced. The adequate enforcement of these requirements forms the sole protection against the distribution of the Japanese beetle by these materials. Nursery stock is one agent by which the beetle may easily be transported into new sections. It is believed that this pest entered the United States in soil around the roots of nursery stock. If our uninfested regions are to be protected from infestations, it is important that adequate provision be made for inspection and certification of all such material moving to points outside of the quarantined area. Millions of plants are certified for shipment annually.

State agencies carry a varying share of the cost of this activity. The inspection and certification work is done by inspectors located throughout the regulated area, usually in regional offices for general service to shippers in that region, and occasionally on the premises of establishments shipping large quantities of material. Inspectors check all non-infested regulated establishments frequently to ascertain that no uncertified stock is received and no infestation of the premises has occurred. Where establishments are actually infested, a 100 percent examination of stock is required to ascertain freedom from infestation before certification can can be granted. If soil is present in the shipment the plants and soil must be subjected to chemical treatment under the inspector's observation.

Nurseries and greenhouses in the quarantined area are classified on the basis of presence or absence of beetle on or adjacent to the individual premises. The requirements for certification of material from the two classes of establishments differ. A very essential part of the enforcement of quarantines for the protection of uninfested regions is the classification of these establishments, which can be determined only by scouting rather than by the use of traps. Inspection work of this type must be done with great care to avoid erroneous classification of establishments so as to not work undue hardship on the producer and at the same time give adequate safeguards against products that may move from their establishments.

This work is done mainly by temporary employees operating under the supervision of experienced Division personnel. The scout crews, consisting of from two to four men, including foremen, are headquartered in various districts where they are trained. All affected establishments in the area are carefully scouted over their entire premises and adjacent area from four to five times during the season, which extends from June to September. Discovery of infestation on such premises results in immediate loss of certificate privilege with consequent tightening of restrictions on the certification of materials. Each Japanese beetle collected by scouts is sent to headquarters for authoritative determination, and the field supervisor makes a field check as soon as possible after the reported find in the interest of the establishment.

It is essential to the effort to retard the spread of the Japanese beetle that we have accurate information as to the possible presence of outlying infestations. To secure this information traps are operated to determine the possible presence and relative abundance of the beetle. The traps are operated in selected localities where infestation is light and at places outside the known infested area, particularly along main highways or at important transportation centers. The prompt location of incipient outlying infestations can be accomplished only by this type of work and any curtailment will, as in the case of St. Louis, Missouri, delay locations of centers of infestation for a number of seasons. Trapping operations begin in the southern states early in June and at later dates in the more northern sections.

Under certain conditions of infestation and particularly in isolated centers of infestation the operation of a large number of traps aids in the reduction of beetles. Control operations of this type are carried on at St. Louis, Missouri, Detroit, Michigan, and Chicago, Illinois. In outlying areas where it is practical to locate sections where there is good reason to believe grubs occur in the soil, the application of certain treatments, such as arsenate of lead, will materially aid in reducing the number of beetles that appear next season. Work of this type is carried on in cooperation with the state or local agencies, under the following programs: (1) Trapping which is usually conducted on a fifty-fifty State-Federal basis; (2) lead arsenate soil treatment in which the State usually provides material and labor and the Federal government technical supervision, operators and special equipment. However, a limited amount of lead arsenate is usually in possession of the Federal Department for emergencies.

The traps are concentrated on known infested premises and adjacent thereto, and field personnel supplement the traps by scouting and hand collections from host plants which is a distinct aid in control.

Lead arsenate is applied as a liquid being mixed with water in a special spray machine and sprayed on the soil at the rate of 500 lbs. of lead arsenate per acre for a distance of approximately 300' from beetle collection location. The spray residue is water-washed from grass and other vegetation immediately. Proper precautions are observed regarding use of poisonous mixtures.

Inspection facilities are now available at convenient locations in the particular region of the regulated area concerned, in order to permit the movement of farm products under certificate. A summary of the conditions of certification follows: (1) When the fruits and vegetables moving via refrigerator cars or motor truck have actually been inspected and found free from infestation, or when the commodities have been handled or treated to rid them of infestation, and have been loaded under protection into pre-inspected trucks or refrigerator cars. Because of the difficulties involved in inspection of refrigerator car interiors those concerned usually choose to fumigate to obtain pre-certified cars. During and after loading, all truck or car openings must be screened. (2) When the commodities have been fumigated under load in a refrigerator car, or other suitable chambers with approved chemicals. Processed or manufactured fruits and vegetables are usually so handled as to permit exemption from these certification requirements.

All of the above must be under the observation of inspectors who must be supervised closely because of the nature of the commodities affected, and the dangers connected with observation of fumigation with dangerous chemicals.

State agencies carry a varying share of the cost of this activity.

To assure that products likely to carry the beetle are being moved only in accordance with quarantine requirements, road vehicle inspection stations are installed at locations on the periphery of the regulated area selected after traffic surveys. On the most important roads 16 and 24 hour service is maintained, and on routes of lesser importance duty is limited to 8 hours, and infrequent checks by "floating" inspectors are made on the least important roads.

All vehicles are halted, the purpose of the inspection is briefly stated, and if no uncertified articles are being hauled the vehicles proceed. However, when uncertified material is involved or infestation in the vehicle is suspected, the vehicle is delayed for inspection or contraband is confiscated. The only financial assistance received is from the State of Virginia which appropriates approximately $2,800 for cooperative road inspection activities.

At the airplane inspection sites at present established at Arlington, Va. (Washington, D. C.), New York City, Philadelphia, Pa., and Harrisburg, Pa., inspection is carried on with the cooperation of all field and airline officials and there is no interference by the Federal employees with airline passengers. The officials cooperate by keeping all plane openings closed as much as possible to prevent accidental entrance of the beetles into the cabins, and by carrying on passenger and freight loadings with as much dispatch as possible. Airline stewardesses and other employees cooperate by inspecting persons and baggage entering the planes.

In order to facilitate the enforcement of the regulations under the Japanese Beetle Quarantine, inspectors are stationed at strategic centers through which pass large volumes of restricted plant material. A knowledge that such inspection check-up is operating serves as a deterrent to would-be willful violators and also as a check on the cooperation offered by the receiving clerks of various methods of parcel transportation. It also serves as a means of informing non-commercial shippers, whose uncertified packages might be intercepted, of the existence of a quarantine. The latter, when possible, are not interfered with but are inspected at the point of interception and allowed to proceed.

Supervising inspectors confer with officials of the mail service and transportation companies to ascertain the routing of this type of material and generally a cooperative arrangement to have such material observed by postal or transportation company employees and held temporarily for the attention and inspection by the transit inspector is made. Such inspectors are now stationed at Boston, Philadelphia, New York and Pittsburgh in cooperation with the Transit Inspection Project of the Domestic Plant Quarantine Division.

(d) SWEETPOTATO WEEVIL CONTROL

Appropriation Act, 1941......................$70,000
Budget Estimate, 1942........................ 70,000

PROJECT STATEMENT

Project	1940	1941 (Estimated)	1942 (Estimated)
Sweetpotato weevil control..	$74,490	$70,000	$70,000
Unobligated balance	510	--	--
Total appropriation...	75,000	70,000	70,000

WORK UNDER THIS APPROPRIATION

Objective: (1) Inspection to determine the extent of the infested area; (2) application of practices designed to control and eradicate the sweetpotato

weevil from commercial sweetpotato-producing areas in the States of Alabama, Georgia, Mississippi and Texas; (3) development of methods for fumigation or treatment of sweetpotatoes to destroy the weevil; (4) cooperation with states in enforcing the regulatory measures provided in the standard state quarantine promulgated on account of this pest.

The Problem and its Significance: In 1937, 843,000 acres produced 75,000,000 bushels of sweetpotatoes with a farm value of more than $65,000,000. About one-fourth of the sweetpotatoes produced in the United States are grown in the states of Alabama, Georgia, Mississippi, and Texas. In these states the outstanding sweetpotato pest is the sweetpotato weevil. The control and eradication of this pest is therefore of major economic importance in this area in order that sweetpotatoes may continue to be produced profitably in these state During the calendar year 1939 nearly 30,000 properties were inspected, 365 of which were found to be infested. Approximately 60 percent of the infested properties have apparently been freed of weevils as indicated by late fall surveys. Inasmuch as eradication of the sweetpotato weevil cannot be accomplished by farmers working individually because of spread from one farm to another and over long distances by shipments of sweetpotatoes and propagating plants, it is necessary that a coordinated effort be made by government agencies. The eradication of local infestations in commercial producing areas is of utmost importance if the sweetpotato industry is to persist.

Plan of Work: Activities designed to accomplish control and eradication of the weevil include (1) inspection to locate and determine the status of the weevil in commercial sweetpotato producing areas; (2) operations to eradicate the pest from infested plantings wherever such measures are applicable; (3) the destruction of infested seed beds and storage banks; (4) cleaning up of fields after harvest; (5) eradication of wild host plants; (6) the continuance of tests to develop methods of fumigation or treatment, and (7) cooperation with states in the enforcement of regulatory measures. In some areas the eradication of the weevil is difficult because of the presence of wild host plants. Extensive work has been done toward eradication of such plants by state-sponsored WPA projects under the supervision of Bureau inspectors.

A considerable staff of inspectors and research specialists is required to effectively prosecute this work throughout the wide area in which operations are conducted. These employees work under the administration of a project leader and a headquarters staff which is centrally located at Gulfport, Mississippi.

At the Sunset, Louisiana laboratory, studies are being conducted on fumigants or other treatments that can be used to eliminate infestation in tubers stored for home consumption or commercial use in areas where infestation occurs. Tests are made with various fumigants to determine the dosage, time, and temperature requirements to kill the weevils in different stages of maturity without injuring the sweetpotatoes for the purpose for which they are intended. Some of these have shown promising results, but further work is needed to determine those which will be most effective against the weevil and least harmful to the potato.

Cooperating States have promulgated necessary quarantines and regulatory orders to prevent the spread of the weevil into noninfested areas and to prevent the reinfestation of localities in which the weevil is being controlled or has been eradicated. The individuals employed under this appropriation are designated by authorized state agencies to act as state inspectors in the enforcement of regulatory measures and cooperate with state inspectors in such work.

(e) MEXICAN FRUIT FLY CONTROL

Appropriation Act, 1941	$167,960
Budget Estimate, 1942	175,460
Increase	7,500

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Increase
1. Mexican fruit fly control operations:				
(a) Grove and packing-house inspection and certification for Mexican fruit fly control	$126,992	$132,660	$132,660	- - -
(b) Spraying and control of Mexican fruit fly in Texas	17,360	21,800	29,300	+ $7,500 (1)
(c) Spraying and control of Mexican fruit fly in Mexico	5,015	5,000	5,000	- - -
(d) Vehicular inspection for Mexican fruit fly control	3,740	8,500	8,500	- - -
Unobligated balance	7,353	- - -	- - -	- - -
Total appropriation	160,460	167,960	175,460	+ 7,500

INCREASE

(1) <u>An increase of $7,500 is requested for supervision of sterilization for control of Mexican fruit fly, as follows</u>:

<u>Objective</u>: To provide additional funds needed to supervise all sterilization activities throughout a 24-hour daily period from the time infestations appear until harvesting is completed in each packing house operating sterilization rooms, so as to insure that the fruit is properly sterilized.

<u>The Problem and its Significance</u>: Larval infestations of the Mexican fruit fly which require the sterilization of infested fruit ordinarily begin in late January or early February and increase in number and in degree throughout the remainder of the harvesting season. The sterilization process requires a minimum of fourteen hours for each room, and an additional period is necessary to provide for the proper loading and unloading of the rooms. In order that the packing houses may operate efficiently, sterilization rooms must be operated on an almost continuous basis and the entire process must be closely supervised so as to prevent excessive heating, which might seriously damage the fruit. Inadequate supervision or delays in the operation of sterilization rooms result in serious losses to the citrus growing industry, which is of paramount importance in the Lower Rio Grande Valley of Texas, by making it impossible for fruit to meet the requirements for shipment out of the regulated area.

<u>Plan of Work</u>: When an infestation is found by an inspector in the field, an infested zone is set aside which may embrace part or all of one planting or, as in many cases, include parts of adjoining plantings. Fruit from this infested zone is harvested under the supervision of an inspector and routed to a packing plant operating sterilization rooms. When this fruit arrives at the plant, it is kept apart from other fruit and cannot be packed until it has undergone the sterilization treatment. The sterilization process exclusively used in packing houses consists of raising the inside temperature of the fruit to 110° F. and holding it at this temperature for a period of six hours. An approach period of eight hours is necessary to bring the entire load of fruit up to the sterilization point. Therefore, in order to complete one sterilization run, a minimum of fourteen hours of operation is required. The method used in sterilizing fruit is to force air with 100 per cent humidity through the room continuously. The heat is obtained by injecting small amounts of steam into the air current. The air is withdrawn through the bottom of the room and is kept constantly circulating. Citrus fruit will stand a temperature of 110° F. without change in flavor or otherwise damaging its keeping or marketing qualities. It must not be permitted however, to become heated to a point in excess of 110° F., as serious damage would probably result. To assure that any eggs or larvae that may be in the fruit are killed, it is essential that the required temperature of 110° F. be maintained throughout the treating period. To know that the treating requirements are carried out an inspector must be on hand to take readings not less frequently than at two-hour intervals during both the approach period and the sterilization period. This increase contemplates the enlargement of the present force of inspectors rather than any change in the plan of work.

WORK UNDER THIS APPROPRIATION

<u>General</u>: This appropriation provides for control and regulatory operations directed against the Mexican fruit fly to protect the fruit growing areas in the United States from danger of infestation by this insect which is known to attack many different kinds of fruits. This includes a broad general program which is discussed as follows:

Objective: To make a tree-to-tree inspection of every citrus tree in the area regulated under Quarantine No. 64 in order to enforce the host-free period provision of the regulations; to operate traps throughout the entire season, which are used to show the presence or absence of fruit-flies and which indicate the probable date of the appearance of larval infestations; to inspect throughout the harvesting season every citrus grove in the regulated area as often as is necessary in order to discover infestations of the Mexican fruitfly and to prevent the shipment of infested fruit from the area; to inspect packing houses daily during the fruit shipping season to insure that fruit being packed, processed, or shipped will be moved in accordance with quarantine regulations; to maintain in both Texas and Mexico, a spraying and clean-up program to guard against local spread of infestation; to maintain vehicular inspection to prevent movement of fruit out of the regulated area except in accordance with the provisions of Quarantine No. 64.

The Problem and its Significance: The Mexican fruitfly is an insect that seriously damages citrus fruit in the Rio Grande Valley of Texas, and in Mexico, where it probably originated, it infests citrus, deciduous, and tropical fruits. This pest was discovered in Texas in 1927 and infestations of varying degrees of intensity have been found almost every year since that date. Within the past few years citrus production within this area has reached a total of between forty-five and fifty thousand carloads annually, and as the harvesting season has of necessity had to be extended at a period of the year when oviposition is normally accelerated, infestations have naturally greatly increased. The purpose of Quarantine No. 64 is to prevent the spread of this serious fruit pest from the regulated area in Texas to other fruit growing regions of the United States, and at the same time, within safe limits, to permit a shipping program which will protect the interests of the producers.

Plan and Progress of Work: At the close of the harvesting season, which normally occurs between April 30 and May 15, the grower is required to remove all mature and semi-mature fruit from the trees, and there is maintained between the close of the harvesting season and the opening of the following harvesting season a host-free period within the regulated area. This host-free period apparently is one of the most effective means of controlling the Mexican fruitfly in Texas, as it removes fruits for oviposition and prevents an increase in the fly population which would infest fruit in the early fall and cause sterilization activities to begin at a much earlier date than is now usually necessary. There are within the regulated area approximately seven million citrus trees on some six thousand properties. The trees on each property must be inspected at the beginning of the host-free period. This is a necessary function and is accomplished by day laborers working under the direct supervision of regular inspectors. This feature of the work annually costs about six thousand dollars for common labor.

Citrus fruit produced in the regulated area of Texas is moved from the area under permits. Before permits are issued for the movement of fruit, groves are inspected at regular intervals by field inspectors,

and if no infestations are found, permits for the unrestricted movement of fruit are issued. In case infestations are found, the fruit is routed through sterilization plants operated by the various packing houses under the supervision of inspectors before it is permitted to be shipped. Approximately nine thousand fly traps are operated continuously in representative groves throughout the regulated area. Packing houses are inspected daily to insure that all fruit being moved from the area is handled in accordance with quarantine regulations.

The area regulated under Quarantine No. 64 is made up of Cameron, Hidalgo, Willacy, Brooks, La Salle, Dimmit, and a part of Jim Wells Counties, Texas. This area is divided into fourteen districts for administrative purposes and inspectors are stationed in these districts in proportion to the amount of work involved. At the beginning of the host-free period crews of day laborers are employed to inspect each tree in every grove within the regulated area and to remove any mature or semi-mature fruit overlooked by the property owner. Approximately four thousand man-days of common labor are required to complete this phase of the work. Approximately nine thousand glass fly traps, especially developed for work on this project, are operated continuously in representative groves throughout the area. These traps serve as indicators of the presence or absence of flies and are of great value in forecasting the probable date when larval infestations are most likely to appear. The traps are baited at weekly intervals with a solution of brown sugar and water. This bait has proved to be the most satisfactory attractant developed by the research division. During the host-free period when field inspectors are not necessary, the traps are operated by the regular inspectors working alone, but during the harvesting season when other work is pressing, day laborers are used to assist the inspectors to speed up the work. The harvesting season begins on September 1 and from that period until the time it closes, which varies from April 30 to June 15, grove inspections must be made at frequent intervals in every grove from which fruit is being harvested for shipment from the area. The purpose of these inspections is to discover the presence or absence of infested fruit, which, if shipped from the area, could cause the establishment of new infestations of the Mexican fruitfly in other fruit growing areas of the United States. This system of inspection has proved to be very efficient, as from 1927, when the first infestation was discovered in Texas, up to the present time no known infestations of the Mexican fruitfly have become established in other fruit growing areas, in spite of the fact that recurrent infestations have been found in Texas almost annually.

The Mexican fruitfly can and probably does fly over considerable distances each year, but because of the geographical location of the area under Quarantine No. 64, it is believed that there is relatively little danger of the spread of this pest in the United States except through the shipment of infested fruit. When infestations are found in a citrus planting, the unrestricted movement of fruit from infested zones is curtailed and the fruit is routed to sterilization rooms operated by the packers within the area under the supervision of Department

inspectors. In order to insure complete compliance with quarantine regulations, daily inspection of packing houses within the area is necessary. Fruit is not permitted to be harvested without being properly inspected and until permits have been issued. Packing house inspections insure that all fruit being moved through these houses has been previously inspected and that permits for its harvesting, packing, and shipping have been issued.

To detect the possible presence of the fruit fly, traps are operated throughout the year. If adult flies are found a posion spray on which the adults feed may be applied in the groves so the adults will be killed prior to laying of eggs. To be fully effective the proper application of this spray is essential and the work must be closely supervised.

No commercial fruit is produced in Mexico adjacent to the Lower Rio Grande Valley in Texas where infestations of Mexican fruit fly have been found. The only fruit trees in adjacent Mexican territory are those in dooryards grown largely for shade or ornamental purposes. Considerable quantities of fruit, however, are shipped from the interior of Mexico into this area for local consumption. Much of this fruit is infested and is a source of infestation of the fruit produced on dooryard and ornamental trees. The presence of this fruit and infestation permits the development of adult flies which may fly across the Rio Grande and infest the fruit grown in the regulated area in Texas. To reduce this opportunity inspection and cleanup work are carried on in Matamoros and other Mexican towns adjacent to the regulated area. These operations may involve the disposition of infested fruits and the application of a poison spray to dooryard and fruit trees. This work is carried on with the hearty cooperation of the Mexican officials and citizens residing in that area.

Inspection of truck shipments

Three highways leave the area in Texas regulated on account of the Mexican fruit fly. Large quantities of fruit are moved over these highways by truck and similar vehicles. To assure that the fruit so moving has been certified as meeting the requirements of the quarantine, road stations are maintained at appropriate locations, in the general vicinity, respectively, of Falfurrias, Rio Grande City and Raymondville.

Before a motor vehicle operator can leave the regulated area with a load of citrus fruit, a permit must be obtained from one of the district offices located in the area. This permit clearly shows the amount of fruit being transported and the destination thereof. Upon arrival at a road station this permit is handed to an inspector, who checks the amount of fruit actually on the vehicle with the amount shown on the permit. The permit is then stamped and one copy is given the motor vehicle operator for his record. If, as sometimes happens, the operator does not have a permit as required, he must return to the regulated area and secure the proper permit if the fruit is being moved in accordance with quarantine regulations; but if the fruit is not being moved in accordance with the regulations, the fruit is confiscated or

other legal action is taken. Through the maintenance of these established road stations at these strategic points, absolute control is maintained over fruit moving by motor vehicle and very little opportunity exists for fruit moving from the area to pass unless it has been properly inspected, certified, and permits for its movement issued.

(f) CITRUS CANKER ERADICATION

Appropriation Act, 1941	$13,485
Budget Estimate, 1942	- - -
Decrease	$13,485

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Decrease
Citrus canker eradication	$13,284	$13,485	- - -	- $13,485 (1)
Unobligated balance	201	- - -	- - -	- - -
Total appropriation	$13,485	$13,485	- - -	- 13,485

DECREASE

(1) A decrease of $13,485 results from the elimination of this item.

WORK UNDER THIS APPROPRIATION

The funds and authorization provided under this item have been an important factor in the eradication operations directed against the bacterial disease of citrus known as citrus canker during recent years when much of the work has been carried on with allotments from emergency funds. The funds have provided for technical advice and supervision of the field work and coordination of the activities conducted by cooperating States and have been accepted as a part of the required sponsor's contribution.

Citrus canker is a highly infectious introduced bacterial disease of citrus trees. It gained establishment in the United States a number of years ago and spread from the area of original discovery in Texas to the citrus-producing regions of the Gulf Coast including Florida. The importance of this disease to our citrus cultures was definitely demonstrated prior to the time when the Department and cooperating States undertook to suppress it. As a result of the cooperative effort during which the cooperating States and individuals have contributed not only funds and means but also thousands of trees which have been destroyed, the disease has been eliminated from all but two localities in Texas and Louisiana remote from commercial citrus plantings. The disease is highly infectious and can be distributed by birds and other natural means.

In the eradication work involving the removal of infected trees, even the instruments used and the clothing of the men have to be disinfected to prevent spread by these means. The operations and inspections to locate the disease have to be carried on under technically trained individuals. The work is carried on in cooperation with responsible State Officials and under state authority. The cooperating states contribute to the work and in the past their contributions alone have been much larger than the amounts provided by the present combined Federal and State appropriations. In addition large numbers of trees have been surrendered by growers without compensation. In Florida alone more than 240,000 grove trees and 2,700,000 nursery trees were destroyed. The disease was eradicated from that State. During the current fiscal year the two cooperating states, Texas and Louisiana, have contributed $16,000 to this work.

During recent years the funds provided by this appropriation have been used principally to provide technical employees to supervise and co-ordinate the work which has been done by funds provided from emergency appropriations and contributed by the states. An important adjunct to the work which has been carried on with the help supplied through emergency funds is the removal of abandoned and escaped citrus trees which occur in areas where infections still exist. These activities have materially aided in the completion of the effort to eradicate the disease and have reduced the amount of inspection that has to be done by trained employees.

During each of the last two seasons the disease has been found on one property while in each of the three preceding seasons infection was found on three properties.

SUPPLEMENTAL FUNDS

Direct allotment

Project	Obligated, 1940	Estimated obligations, 1941
Emergency Relief Appropriation Acts of 1938:		
Citrus canker eradication..............	$62,887	$43,860

(g) GYPSY AND BROWN-TAIL MOTH CONTROL

Appropriation Act, 1941......................$375,000
Budget Estimate, 1942........................375,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Inspection and certification for gypsy and brown-tail moth control..........................	$98,820	$99,282	$99,282
2. Control operations for gypsy and brown-tail moth control....	273,440	275,718	275,718
Unobligated balance..............	2,740	- - -	- - -
Total appropriation........	375,000	375,000	375,000

WORK UNDER THIS APPROPRIATION

General: The work under this appropriation is carried on for the purpose of control and prevention of the spread of the gypsy moth and brown-tail moth from the territory east of the Hudson River and any outlying infestations to other parts of the United States in order to afford protection to uninfested regions. It is divided into the following projects.

Project 1. Inspection and Certification for Gypsy and Brown-Tail Moth Control:

Objective: To inspect and certify all articles as restricted under Quarantine No. 45, consisting of nursery stock, stone and quarry and forest products, including Christmas trees and greenery, when moved from areas under regulation, in order to prevent artificial spread to non-infested sections of the country.

The Problem: The inspection and certification of products under gypsy and brown-tail moth regulation has been carried on throughout the areas under quarantine since 1912. During the fiscal years 1938, 1939, and 1940, the areas under regulation have been approximately constant and no extensive changes are contemplated during the years 1941 or 1942.

Comparison of the amounts of nursery, stone and quarry, and forest products, including Christmas trees and Christmas greenery, inspected and certified during the past three calendar years - 1937, 1938, and 1939 (such reports are tabulated on the calendar year) - indicates no reduction, the trend being toward an increase, while the amounts of infestation removed from such materials during 1939 indicate a marked increase over 1937 and 1938.

The tables inserted at the end of the textual matter on this project, indicating the amounts of such materials actually inspected and certified, together with the number of shipments made by "permit" shippers, where strict supervision of establishment conditions is necessary, will point out that there has been no total reduction in the amounts of such materials inspected and permitted for shipment to areas not now infested.

Significance: Discontinuation of Quarantine No. 45 would allow movement of infested products to non-regulated areas throughout the country, probably resulting in state embargoes of products now under regulation. The placing of state embargoes would prohibit, or at least greatly delay movement of articles now under regulation, tending to reduce shipments, and would directly affect, financially, the preponderance of small producers and employees. At the present time the movement of articles under regulation such as lumber, stone and quarry products, nursery stock, evergreen boughs, Christmas greenery and Christmas trees is not appreciably hampered by quarantine regulations.

Plan and Progress of Work: Inspection and certification requirements affecting products liable to gypsy moth infestation have been in effect since 1912. During this 28-year period, a very definite method of procedure has been perfected in regard to inspection of each kind of inspected product. Areas under regulation have been apportioned into eighteen (18) districts of "work-areas", one or more inspectors being assigned to each; the number depending upon the type and amount of inspected material involved, the severity of the infestation and the number of shippers. A total of twenty-six (26) inspectors are assigned to the 18 districts and during seasonal periods of heavy movement of restricted material, additional temporary, experienced inspectors are employed. The work in each district is supervised directly in order that all project work may be coordinated and efficiently directed; one supervisor each is assigned and responsible for the work in six districts. Both supervisors and inspectors are informed as to changes in method and procedure by actual field contacts and periodical group and district meetings.

Although the inspection and certification project has not received direct financial assistance from private or other public sources, monies spent for clean-up of infestations within the area by federal, state and private agencies have unquestionably assisted, not only in checking the spread of the insect, but also in reducing the infestation within certain areas under regulation.

Safe and practical methods of disinfestation are being worked out which, it is believed, may be applied to certain products under regulation. The perfecting of such methods of treatment would tend to relieve both inspectors and shippers of the detailed piece-by-piece inspection; would be more economical in application; and would allow certification of some products that could not otherwise be inspected. These various methods of disinfestation include the use of fumigants, disinfectants, and mechanical devices.

Products Inspected and Certified under Gypsy and Brown-tail Moth Quarantine No. 45 During Calendar Years of 1937, 1938, and 1939

Type of Product	1937	1938	1939
Nursery-grown stock (plants)	6,986,095	9,193,979	10,054,050
Forest Products			
Lumber (bd. ft.)	44,891,932	34,997,628	52,262,199
Reels	23,316	32,984	43,787
Shavings (bales)	39,420	39,117	49,595
Shrub & vine cuttings	12,523	2,960	7,924
Misc. (carlots)	43	29	56
Misc. (trucks)	2	2	5
Misc. (tons)	20	258	1,213
Barrel, parts, crates, etc. (bundles)	33,454	47,037	23,490
Misc. material (pcs., bags, boxes, bundles, cartons, etc.)	769,062	262,625	343,768
Lags (bundles)	1,236	7,732	5,967
Logs, piles, posts, poles	1,972,172	575,040	999,270
Wood (cords)	53,004	43,430	50,126
Evergreen Products			
Boughs, twigs & greens (boxes or bales)	51,619	39,237	43,466
Christmas trees	763,105	343,398	448,246
Misc. (box, bales, bags)	5,092	6,310	4,819
Misc. (trucks)	2	1	6
Roping (feet)	6,218	4,950	53,700
Laurel (boxes)	9,768	11,890	6,921
Stone and Quarry			
Crushed rock (tons)	35-1/4	956	85
Curbing (running ft.)	66,404	29,625	34,459
Feldspar (tons)	17,749	1,399	2,000
Granite (pcs.)	162,668	100,480	436,548
Granite (tons)	13,655	28,899	24,812
Monumental stone (pcs.)	19,245	21,158	18,171
Grout (tons)	58,649	11,938	3,197
Limestone (tons)	1,682	60	30
Marble (pcs.)	213	602	276
Marble (tons)	60	0	0
Paving blocks	1,454,408	529,413	447,876
Misc. (pcs.)	31,088	6,625	11,055
Misc. (cars)	10	9	33
Misc. (tons)	88	253	1,300

Products Permitted under Quarantine No. 45
During Calendar Years 1937, 1938 and 1939

	Number of Shipments		
Type of Product	1937	1938	1939
Forest	6,654	6,374	6,508
Stone and Quarry	77,784	69,948	56,063
Nursery	1,152	1,268	193

(December 31, 1937, 242 shippers were under permit;
December 31, 1938, 222 shippers were under permit; and
December 31, 1939, 205 shippers were under permit).

Project 2. Control Operations for Gypsy and Brown-tail Moths:

Objective: To protect tree growth from the injury which will be caused in most sections of the United States if the insects are permitted to spread and become generally established.

The Problem and its Significance: Methods of treatment have been applied and many years of experience has demonstrated the ones which are the most successful and economical. It is necessary to improve these methods whenever possible. The principal means used at the present time consist of careful examination of territory to locate infestations, which means examination of all tree growth both rural and urban as well as forest areas, and the treatment of infestations wherever found. The following measures have been applied singly or in combination, depending on local conditions where the infestation occurs, the cheapest methods being used to secure effective results; scouting which is carried on for the most part during the fall, winter and spring months, treatment of egg clusters with creosote, thinning of infested areas by removal of worthless trees and species which are the most favored as food for the insect, crushing caterpillars on trees which have previously been banded, and the application of poison spray to kill the pest. The purpose of the work is to destroy all living forms of the insect so that spread may be prevented and extermination of the pest accomplished in the Barrier Zone and outlying isolated infestations. The successful carrying through of this work results in making it unnecessary for outlying states to expend funds to protect their trees from this insect. This protection amply justifies expenditure of funds by the Federal Government for country wide protection. The infested states are expending more than a million dollars annually to combat this pest. Their work is done primarily in the residential, park and recreational areas, and along streets or avenues in order that this highly desirable tree growth may survive. Little work is being done in the woodland areas where general infestation occurs because the cost of intensive treatment is usually prohibitive, and areas defoliated have reached over 600,000 acres in a single year. The species which are most

favored are disfigured by loss of foliage and succumb from repeated defoliation and even partial defoliation during a single year causes retardation of growth and frequently the death of twigs and branches.

Plan and Progress of Work: The Federal work is concerned primarily with the examination and clean up of infestation in the Barrier Zone and any outlying outbreaks of the gypsy moth. The Zone extends east of the Hudson River in New York to the Canadian Border covering territory about 30 miles in width, approximately one half of which is in Western Vermont, Massachusetts and Connecticut. Cooperation with the states concerned includes correlated control programs and the assembling of data, statistics and information bearing on the entire problem. In August, 1933 emergency funds from the NRA and later from the WPA were granted and this has made possible the coverage of extended areas that could not have been handled otherwise, and furnished work for many unemployed men. The arrangement under which this work was organized was that the Bureau would handle the administration and supervision of the work, furnish the trained personnel and such office operating facilities, equipment and supplies as could be financed by the available regular funds. The emergency organization supplied labor from relief sources together with supplies and equipment and such facilities as were necessary in order to carry through the work.

Since the Barrier Zone was established in 1923 the balance of the country has been protected from infestation. The New Jersey infestation has been eliminated and areas, particularly in the northern part of the Barrier Zone in New York and Vermont, have been freed from infestation and an equivalent area adjoining the eastern border of the Zone aggregating 889,000 acres in the northern part of Vermont and in Connecticut have been scouted and treatment applied for the purpose of giving additional protection to the original Zone. Work in the Zone in New York has been supervised principally by the Conservation Department of that State and a relatively small number of infestations have been found and treated. Since 1935 personnel financed by WPA funds, in addition to the state force, have worked in that area and good progress has been made. During the past year many scattered infestations were found in Rensselaer County which undoubtedly resulted from windspread from the east. In cooperation with the Bureau, a State Quarantine is being operated by the State Department of Agriculture in Pennsylvania so that materials likely to carry the gypsy moth either within or to points outside the infested area are inspected before movement is permitted. The area which was at first seriously infested has been reduced and it has been possible to modify the quarantine within the last two years to permit the freer movement of material without danger of transmitting infestation. In 1939 shipping restrictions were completely removed from 3 townships. No defoliation of trees has been reported in the Pennsylvania area since the year the infestation was first found in 1932.

Allotments have been made available from emergency funds for the control of the gypsy and brown-tail moths. The supervision of this work is provided by the organization employed under the regular appropriation. Without this supervision the activities under the emergency

funds could not be carried out. The funds for 1942 will be used for the continuation of this program that has been carried on during the last few years and the estimate contemplates that emergency funds will continue to be available for this work.

SUPPLEMENTAL FUNDS

Direct Allotment

	Obligated, 1940	Estimated obligations, 1941
Emergency Relief Appropriation Acts: Control and prevention of spread of gypsy moth......	$731,095	$405,000

(h) DUTCH ELM DISEASE ERADICATION

Appropriation Act, 1941	$400,000
Budget Estimate, 1942	300,000
Decrease	100,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Decrease
1. Dutch elm disease eradication:				
(a) Scouting to locate the Dutch elm disease	$379,714	$315,000	$215,000	- $100,000 (1)
(b) Identification of disease in trees suspected to be infected with the Dutch elm disease	40,469	34,000	34,000	- - -
(c) Enforcement of quarantine on Dutch elm disease	5,000	5,000	5,000	- - -
(d) Coordination of State work on the Dutch elm disease	44,465	20,000	20,000	- - -
(e) Removal of diseased, dead, and dying trees	9,981	6,000	6,000	- - -
(f) Investigations and surveys on virus disease of elms prevalent in the Ohio Valley	19,984	20,000	20,000	- - -
Unobligated balance	387	- - -	- - -	- - -
Total appropriation	500,000	400,000	300,000	- 100,000

DECREASE

(1) A decrease of $100,000 in this item will be effected by curtailment of scouting to locate the Dutch elm disease.

WORK UNDER THIS APPROPRIATION

Objective: The objective of the work under this appropriation is to prevent the loss of what is generally accepted as this country's most valuable shade tree, the American elm, due to the Dutch Elm Disease,

Ceratostomella ulmi; (1) by preventing entrance of more disease into this country and transportation of disease from infected to non-infected areas; (2) by locating all disease centers in the states exposed to the disease as result of movement of imported logs and of spread from established areas; (3) by eradicating immediately all centers where epidemic form has not developed; (4) by reducing spread from and within severe disease areas by suppression or control.

The work under this appropriation does not include step 4 as such work is largely supported by W. P. A. allotments.

Problem: During the last 20 years the Dutch Elm Disease has caused the wholesale loss of elms on the European Continent. The American elm, Ulmus americana, has proved to be one of the most susceptible elm species. Limited field observations and experimental tests have shown all native elm species of the United States to be subject to attack and death.

Between 1926 and 1933 there were imported into this country about 600 elm burl logs from Europe. Logs which were examined in 1933 carried the Dutch Elm Disease fungus and European elm bark beetles which carry the disease. These logs entered at New York City; Baltimore, Maryland; Norflok, Virginia; and New Orleans, Louisiana, and most of them were carried by railroad to the Mid-west. This movement involved 68 shipments on 14 railraods, over about 12,000 miles of routes, and 20 states. Elm trees in the states of Alabama, Arkansas, Delaware, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, Virginia, and West Virginia, were thus exposed to the Dutch Elm disease. These logs were processed or cut into veneer at 23 plants in Illinois, Indiana, Kentucky, Louisiana, Maryland, Missouri, Ohio, Pennsylvania, New York, Tennessee, and Virginia.

The Dutch Elm Disease has been found in 9 states, as follows: Connecticut, Indiana, Maryland, New Jersey, New York, Ohio, Pennsylvania, Virginia, and West Virginia. In an area with a radius of about 75 miles around New York City the disease developed into an epidemic. In 14 centers, as follows: Old Lyme, Connecticut; Indianapolis, Indiana; Baltimore, Brunswick, and Cumberland, Maryland; Binghamton, New York; Athens, Cincinnati, Cleveland, and Hockingport, Ohio; Wilkes-Barre, Pennsylvania; Norfolk and Portsmouth, Virginia; and Wiley Ford, West Virginia, the disease became established but has not developed into epidemic proportions. Success in eradication is apparent in ten of these fourteen centers. Four of the centers were not found until recent years but it is possible to report progress in these centers.

The European elm bark beetle, one of the principal carriers of the disease, was introduced into the United States a number of years ago and has become established in New England, Middle Atlantic, Potomac Valley, and Ohio Valley states. The infestations in these four general areas have not yet joined into a continuous area of infestation. The native elm bark beetle, Hylurgopinus refipes, another important carrier of the disease, has been reported over a wide area and probably exists throughout the natural range of the elm.

The American elm, the most important elm from the standpoint of use and value as a street, park, highway, and farm elm, extends naturally over almost the entire area of the United States east of the Rocky Mountains and has been planted extensively in the Pacific Coast states. Other native elm species extend this range to the South and Southwest making a continuous stand of elm by means of which the disease may readily spread nation wide.

Prompt action is urgently needed because the Dutch Elm Disease is a deadly threat to a great national resource. Through means which no state was able to control, the Dutch Elm Disease has become established in nine states, a portion of the elms in fourteen other states have been already exposed and elms in the other twenty-five states may be exposed to the Dutch Elm Disease if it is not controlled or eradicated. Only by Federal action can a state not now infected be protected from the disease beyond its border. Work within the disease area which involves several states must be closely coordinated.

Significance: The American elms have values that cannot be measured in dollars and cents; that is, (a) the sentimental value of certain elms to individual owners and families, (b) the cultural value of historic and beautiful elms to many communities, and (c) the health values of many park and street elms to congested city dwellers. The American elms have real values which can be measured in dollars and cents; that is, (a) the appreciation of real estate values of homes and farms with lawn, street, highway and field elms, (b) the invested value in elms made by owners, cities, etc. for planting and yearly care, and (c) the replacement value as represented by the cost of removing hundreds of thousands of dead elms along streets and highways for public safety and replacing them with some substitute planting.

The loss of elms valuable for a variety of reasons, may actually be serious personal or community losses, and taken collectively represent losses of irreplaceable national assets. A city with shaded streets and parks is greatly preferred to a treeless city. A large elm in a park that offers shade to a dozen people on summer days for 100 years has its value measured in human lives and not just dollars. Although not especially suited to narrow streets, the American elm is probably the most widely used park tree and wide street or boulevard tree. The American elm is an American heritage; its loss would be great and irreplaceable.

Real values of America's elms may not be as great as the intangible values just mentioned, but real values are more readily recorded. In 1936 a nationwide survey of elm populations and values was made with the help of over 1,600 city officials in all 48 states. This census indicated a total of 25,000,000 elms as shade trees with an estimated value of about $660,000,000. In this same survey the timber and cordwood value of commercial elm stands was placed at about $40,000,000, a value relatively insignificant compared to the aesthetic and real values of shade tree elms.

On the basis of the known distribution of one of the principal bark beetle carriers of the Dutch Elm Disease, the elm shade tree values may be grouped according to these four districts:

	Shade Tree Values
New England States (Conn., Maine, Mass., N. H., R. I., Vt.)	$ 155,554,121
Atlantic States (Del., N. J., N. Y., 1/2 Penna.)	67,151,062
Potomac Valley States (Maryland, Virginia, 1/2 W. Va.)	12,467,762
Ohio Valley States (Ohio, Ind., Ill., Ky., 1/2 Penna., 1/2 W. Va.)	130,440,165

This grouping of values is most significant because the Dutch Elm Disease is known to exist in two centers in upper and center Ohio Valley, at one center in the upper Potomac Valley, and at two centers in the Susquehanna Valley in the Middle Atlantic States. The Major Disease Area has extended in New York and Connecticut to within a few miles of Massachusetts and the Dutch Elm Disease may spread into the New England area where this bark beetle occurs.

While the threat of the Dutch Elm Disease hangs over America's elms, planting of elms along streets and highways has been greatly curtailed. In the place of elms, in many places less suited trees have been planted or no planting has been done. This condition has frozen the movement of elms from commercial nurseries and has resulted in many nursery elms becoming a liability in many parts of the United States.

The timeliness of thorough control and eradication efforts is very significant. Much precious time has already been lost by inability to determine the full extent of spread. In the last two years, with more funds available, the work has been extended into the Border Zone around the known infested area and resulted in finding disease centers that were established several years earlier.

Plan of Work: The principles of the Dutch Elm Disease Eradication Program are based upon the nature of the disease and insect carriers as determined by research work in Europe and the United States. The disease organism works inside the outer wood tissues and the bark beetles breed in the tissues between the bark and wood. There is no known cure for a diseased tree and no known method for preventing a tree from being attacked in the presence of the disease-insect combine. The disease and the bark beetles attack only elm trees. The most practicable way of saving America's elms is by destruction of disease sources before the disease is spread from such sources by bark beetles or other agencies.

Since 1933 to the present time work has been carried on in the Major Disease Area around New York City and in numerous isolated areas. In every isolated area where the program has operated for a sufficient number of years, success has been attained. In the areas more recently

located, definite progress has been made. In the Major Disease Area where the work has been adequate, the number of diseased trees has been markedly reduced and the epidemic condition has been suppressed and is under control. In the Outer Disease Zone and in the Border Zone, sufficient work has not been done to satisfactorily find the limits of the disease and to completely stop spread.

The job of locating diseased and beetle infested trees is called "Scouting". The disease produces wilt symptoms, but such symptoms are not always present, and may not develop for a year or more after infection takes place. It is necessary to examine a tree two or more times yearly for several years, to be reasonably sure of detecting symptoms as they develop and before the dying is so advance as to permit the trees to become sources of spread. Scouting for bark beetle material is coordinated with disease scouting and sanitation removal work for the greatest efficiency. Increases in work area automatically increases the amount of necessary scouting. When outlying centers are eradicated or border areas are determined to be disease free and spread of disease from center of major area is stopped, there can be a great reduction in the amount of scouting work.

The timely removal of known Dutch Elm Disease trees is very important - especially in the outlying centers around the major area and in the isolated areas. Compared to cost of scouting and bark beetle control, the cost of diseased tree removals is very small. Inasmuch as it involves the destruction of what may be considered by the owner to be valuable trees, the work is done under the condemnation powers of the state. For this reason, the actual destruction must be preceded by scouting for and sampling of the tree, laboratory diagnosis of representative samples, and clearance by state officials. Because the above conditions must be met and because trees are generally scattered over a large area, the cost per tree is increased and the supervision of this phase of the work must be thorough.

The removal of bark beetle material is called "Sanitation Work". The material destroyed may harbor the disease organism in an inactive stage as well as bark beetle carriers. For this reason, the work is highly important not only in the isolated and outlying centers, but in suppressing the disease in the center of the major area. Once the material which has accumulated over many years is cleaned up, the job of keeping the bark beetle material at a satisfactory minimum is not so costly. Inasmuch as sanitation work is done largely by W.P.A. personnel, located in the center of the major area, the beetle material removal work in the border zone has not been completed. Until it is completed, the menace of unlocated centers will be great and the job of eradicating disease centers will be difficult.

The mapping of scattered valuable elms and elm groups or areas and the removal of low value scattered elms is termed "Selective Work." The objective of this work is to reduce the cost of scouting such areas year after year. The elm elimination in large areas of scattered elms may serve as a barrier against spread of the disease across such areas.

The cost of such work may be approximately that of two or three seasons' scouting, but would reduce all subsequent scouting 70 to 95%. The high initial cost and the fact that areas where such work should be done are generally outside the area where W. P. A. men are available, has seriously curtailed this type of work.

The search for suspected elms, laboratory identification of the causal organism, emergency removal of diseased elms, enforcement of quarantine, and administration of the eradication work has been divided between W. P. A. and Regular funds depending to a considerable extent upon the availability of W. P. A. labor, the type of men required, and the nature of work to be performed. From 1933 to June 30, 1940, total Regular funds contributed to support of the Dutch Elm Disease Eradication Project $1,982,190; the total W. P. A. contribution for the same period was $14,971,496. A total of $563,190 was contributed by emergency agencies, such as - ECW, CCC, NRA, CEA, FERA, PWA. The States of Connecticut, New York, New Jersey, Ohio, Pennsylvania, Indiana, Maryland, and Massachusetts have contributed a total of $1,178,814.

The $966,482 of emergency relief funds made available for the fiscal year 1941 is scheduled to be utilized largely in the present known infected region in the search for diseased and beetle infested elms, laboratory identification of the disease organism, and the removal and destruction of diseased elms and elm material that is or may soon become infested by bark beetles in an area of approximately 8,700 square miles.

SUPPLEMENTAL FUNDS

Direct Allotment

Project	Obligated, 1940	Estimated obligations, 1941
Emergency Relief Appropriation Acts: Eradication of Dutch elm disease..................	$2,018,367	$966,482

(i) PHONY PEACH AND PEACH MOSAIC ERADICATION

Appropriation Act, 1941........................$89,800
Budget Estimate, 1942.......................... 89,800

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Eradication of phony peach and peach mosaic..................	$89,645	$89,800	$89,800
Unobligated balance.............	155	- -	- -
Total appropriation..........	89,800	89,800	89,800

WORK UNDER THIS APPROPRIATION

General. This appropriation provides for the control and eradication of two important diseases of peach. One of these diseases is known as phony peach and is a serious infectious disease which makes peach orchards unprofitable by reducing both the size and quality of the crop. The other, peach mosaic, is a virus disease which in relation to the United States is of comparatively recent appearance. It injures the tree by causing it to become stunted and produce undersized fruit which is hard, irregular in shape and of reduced commercial value. The only method of combating these diseases is to remove and destroy the tree. These operations are carried on in cooperation with state agencies. The appropriation also provides for cooperation with state authorities in the certification of products of the infected areas to meet the requirements of state quarantines.

Plan of Work: The accurate determination of trees infected with phony peach disease or with the peach mosaic disease requires special training. One of the important phases of eradication work carried on under this item in cooperation with the states includes inspections to locate diseased trees. These operations are conducted by trained inspectors employed under this project. The removal of diseased trees is carried on under the authority of the cooperating states and with funds or means supplied by them or from emergency funds allotted to the Bureau for this purpose. To prevent long distance spread through the shipment of nursery stock containing diseased trees, intensive inspections are made in and around nurseries that produce peach nursery stock. The shipment of nursery stock from areas in which the disease occurs is prohibited by state quarantines unless it is produced under specific sanitation conditions. Inspectors employed under this item cooperate with the state agents by giving them assistance which will aid them in certifying products in compliance with state quarantines. The Bureau has been instrumental in bringing about standardized phony peach disease quarantines in all the affected states.

During the past 4 growing seasons, approximately 55,000,000 orchard trees were inspected for phony disease in 15 Southeastern states, and 302,549 phony infected trees removed. In addition it is necessary to inspect annually in the neighborhood of 664 nurseries, growing approximately 26,000,000 peach trees in 203 counties of the phony infected states together with all peach trees in the one mile environs of these nurseries involving more than 2,000,000 full grown trees.

The phony peach disease has been found in the States of Alabama, Florida, Georgia, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee and Texas. A few infected trees have also been located in Maryland, Indiana, Oklahoma and Pennsylvania, although as a result of intensive inspection and eradication work, the disease has apparently been eliminated from such states, as well as from rather extensive areas in the remaining infected states. The infection in most of the states is scattering with the exception of that which occurs in the main peach producing areas of Georgia, Alabama, Tennessee and South Carolina. The disease was first located in the State of Georgia. The peach mosaic disease has been found in Colorado, Utah, California, New Mexico, Arizona, Texas and Oklahoma.

Emergency funds for relief purposes have been allotted to the Bureau to carry on work against both of these diseases. The continuation of such allotments is vitally necessary to any large-scale program of eradication, as the regular funds are sufficient only for technical and supervisory features. The work conducted with emergency funds has made it possible to make very substantial progress in the elimination of diseased trees. In certain areas, particularly sections where the phony peach occurs, large numbers of abandoned trees and seedlings which may harbor the disease have also been destroyed.

SUPPLEMENTAL FUNDS

Direct Allotments

Projects	Obligated, 1940	Estimated obligations, 1941
Emergency Relief Appropriation Acts		
Control of phony peach disease.....	$199,390	$93,624
Control of peach mosaic disease....	140,499	83,800
Total........................	339,889	177,424

(j) FOREST INSECTS

Appropriation Act, 1941..........$212,500
Budget Estimate, 1942........... 212,500

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Investigations on forest insects:			
(a) Bark beetles attacking forest and shade trees.........	$42,000	$31,000	$31,000
(b) Insects which feed on foliage of forest and shade trees..........................	31,500	27,000	27,000
(c) Insects which bore through the wood and bark of forest and shade trees...............	8,000	7,000	7,000
(d) Sucking insects which attack forest and shade trees..........................	7,000	7,000	7,000
(e) Insects attacking forest trees in nurseries, plantations, and areas of natural reproduction..................	5,500	4,000	4,000
(f) The relation of climatic factors, such as heat, cold, moisture, etc., on forest insect populations............	4,500	4,000	4,000
(g) Insecticides for the control of insects attacking forest and shade trees.........	6,000	6,000	6,000
(h) Injection of chemicals into the sapstream of the tree for the control of bark beetle infestations and for the treatment of green trees to prevent insect attack upon the utilized wood.............	3,200	3,000	3,000
(i) Insects affecting forest products.....................	12,500	8,500	8,500
(j) Habits and development of methods for control of termites........................	12,500	12,500	12,500
(k) Value and use of introduced and native parasitic and predacious enemies upon introduced and native forest insects......................	5,000	5,000	5,000

Projects	1940	1941 (Estimated)	1942 (Estimated)
Investigations on forest insects – Continued:			
(l) Importation of natural enemies of forest and shade tree insects.................	$1,781	– – –	– – –
(m) Surveys to locate and determine the status of insect pests of the forests and the giving of advice to land-managing agencies on planning and conducting necessary control work....................	60,000	$48,500	$48,500
(n) Relation of insects to the Dutch elm disease............	24,000	21,500	21,500
(o) Dissemination of information to the public on methods of controlling forest and shade tree insects, including general inquiries on this subject....	27,617	27,500	27,500
Unobligated balance...............	2,002	– – –	– – –
Total appropriation.........	253,100	212,500	212,500

WORK UNDER THIS APPROPRIATION

General: This appropriation provides for investigations on insects injurious to forest and shade trees and forest products and for the determination of methods for controlling these pests. It provides for giving advice to land managing agencies on methods of controlling insect pests in forests and for surveys to develop facts regarding infestations and the areas where the control operations should be carried on. It also provides for cooperating with the land managing agencies in planning and directing campaigns to control outbreaks of insects which may affect large forested areas.

Objective: To conduct investigations on the biology of insects injurious to forest and shade trees and to forest products and to develop methods of control for these pests. This work serves as a basis for surveys to develop facts regarding infestations of injurious insects in national forests, national parks, other public lands, and on private timberlands, preparatory to giving advice to the land managing agencies as to when and where control operations should be carried on and as to the methods of control to be used. In addition it provides for cooperation with the land managing agencies in the technical direction of control campaigns for suppressing outbreaks of these insects and in the application of forest management practices that will tend to prevent outbreaks of destructive insects.

The Problem: Insect damage to forest and shade trees and to forest products in the process of manufacture or in use has been variously estimated from $100,000,000 to $150,000,000 a year. The greater part of this loss is preventable. Of first importance is the protection of the valuable stands of mature timber which are being held in our national reservations or on private lands. This can be accomplished in most instances by means of direct control methods recommended by this Bureau and which are gradually being improved. Prevention of the losses to stands of second growth timber is largely a matter of forest management by methods being developed through cooperative activity of this Bureau, the Forest Experiment Stations, and certain of the Universities. Such work is rapidly increasing in importance and is receiving recognition from owners of forest land. A third problem is the prevention of damage to forest products, such as pulpwood, poles, posts, crossties, green logs, lumber and wood in buildings. This loss is almost entirely preventable by means of proper methods of handling the material and by sound practices in construction and use. A fourth problem of ever increasing importance is the protection of esthetic values represented by the timber stands in parks, scenic areas, camp grounds and recreational areas. Here an intensive degree of direct control can be applied because of the considerable values at stake.

More complete information regarding the biology of the insects and the ecological factors which regulate their abundance must be obtained. There is much to be learned about methods of preventing increases in forest insect abundance as well as methods of checking outbreaks that do develop. Finally, there is the problem of getting the necessary information into the hands of the timber owners and operators and insuring that they use this information in an effective manner.

Significance: The protection of forests against destruction by insects is one of the most important conservation problems facing the country today. In most sections of the country, particularly in the valuable pine stands of the western states, insects kill more timber than is destroyed by fire. This is largely because fire prevention and control have been given more nearly adequate financial support with the result that effective methods have been developed for reducing losses by fire. The amount of funds available for developing methods of forest insect control has been very inadequate and there is much to be done before insect losses can be reduced to a point where they will not cause such an alarming drain on this valuable natural resource.

Plan and Progress of Work: Nine field laboratories are maintained for conducting investigative studies and service work in connection with forest insects. These laboratories are located at the following points: New Haven, Connecticut; Morristown, New Jersey; Asheville, North Carolina; New Orleans, Louisiana; Columbus, Ohio; Milwaukee, Wisconsin; Coeur d'Alene, Idaho; Portland, Oregon; and Berkeley, California. Two of these, one at Morristown and one at Columbus, are restricted to the study of specific problems - the transmission of the Dutch elm disease and the elm virus disease respectively. The others are regional laboratories which in addition to their research work provide technical

service to the land managing agencies of the Federal Government and to private owners in the control of insect outbreaks in specified regions.

Four of the eastern laboratories located in Milwaukee, New Haven, Asheville, and New Orleans, are particularly active in their cooperation with the Regional Forest Experiment Stations in the development of forest management methods for preventing destructive insect outbreaks in second growth forests. In these regions where there are no large bodies of mature timber, protection of the future crops must depend primarily on the prevention of destructive outbreaks. It is rarely that these growing stands have sufficient value to justify the expenditures of large sums in insect control by the use of insecticides or other direct methods. Considerable progress is being made in developing methods of preventing serious losses by such insects as the spruce budworm, gypsy moth, white pine weevil, pales weevil, white grubs, locust borer, and tip moths. Effort is also being made to increase the numbers and effectiveness of the natural enemies of destructive insects by introducing, propagating and colonizing the various parasites and predators that are found to be capable of attacking the injurious species of insects. Another line of very important work at the Asheville and New Orleans laboratories is that devoted to study of methods of preventing damage by termites in buildings and by powder-post beetles and other boring insects that cause large economic losses in lumber and other forest products.

The three laboratories in the west, located in California, Oregon, and Idaho, are concerned primarily with the study of bark beetles and with developing methods for preventing or controlling outbreaks of these exceedingly destructive insects.

The following is a brief description of the most important work being conducted in each of the work projects financed by this appropriation:

(a) Bark beetles attacking forest and shade trees: Bark beetles destroy from 3 to 6 billion board feet of mature pine, Douglas fir and spruce annually, representing a stumpage value of 20 to 30 million dollars and a much larger sum if considered in terms of finished products. Such losses threaten the very existence of the lumber industry and dependent communities in certain areas. The most serious losses occur in the pine forests of the western states but sporadic outbreaks also take place in the South and Northeast. There are many different species of bark beetles and the various kinds attack different species of trees. The habits of the various species differ and the methods of control differ with the species and also with the kind of tree attacked. The most important species belong to the genus *Dendroctonus*.

As a result of previous work of this Bureau, survey and control methods have been developed that, when applied, enable the timber owners to keep the amount of losses caused by bark beetles at a much lower level than would otherwise be the case. This progress has been made possible as a result of basic biological information that has been accumulated regarding the various species of bark beetles. Because of differences in their habits, it is necessary to use methods of control

that are particularly adapted for each species. Control measures formerly recommended consist largely of felling the trees and removing and destroying the bark so as to kill the beetles under the bark and thus prevent the broods migrating and attacking other healthy green trees. These methods are rather costly and can only be carried out economically in valuable timber. Consequently further studies on the habits of the beetles and experimental work in control are required to develop cheaper and more effective methods. Some of these control methods in which progress is now being made are: (1) the use of penetrating oils in which toxic elements are dissolved and which can be sprayed on the bark so as to kill the insects in or under the bark; (2) the use of chemicals introduced into the sapstream of the trees; and (3) the marking of bark beetle susceptible trees for utilization prior to attack and destruction by the insects.

(b) Insects which feed on foliage of forest and shade trees: Defoliating insects destroy large quantities of timber by eating the foliage from the trees. By far the greater number of these are native to the United States although some very important pests, such as the gypsy moth, the European spruce sawfly and the elm leaf beetle, have been introduced from foreign countries. Control of these insects may be accomplished indirectly by modification in methods of managing the forest, so as to create conditions unfavorable for the multiplication of these pests, or directly by the application of arsenical sprays or dusts. Investigations of these insects are aimed at developing cheaper and more effective methods of controlling or preventing outbreaks. At the present time efforts are concentrated on studies of the gypsy moth, spruce budworm, forest tent caterpillar, European spruce sawfly, and the pine sawflies. Most of this work is being conducted in New England and in the Lake States.

(c) Insects which bore through the wood and bark of forest and shade trees: Certain kinds of insects, particularly beetles, bore under the bark and into the wood of forest and shade trees, resulting in weakening or even death of the trees. These borers are especially injurious in plantations and in shade trees. Some attack only trees that are in a weakened condition while others attack healthy trees - those of the former group are often associated with injuries caused by defoliating or sapsucking insects.

Studies are being made of cultural methods of growing black locust so as to avoid much of the injury caused by the locust borer. This insect has completely ruined a large proportion of the locust plantations throughout the Ohio Valley and parts of the northeastern states. Locust grown on good sites is comparatively free from injury but in recent years it has been planted very extensively on poor, eroded soils where severe borer injury is almost certain to occur.

The hemlock borer has been associated with the dying of over 50 million board feet of mature hemlock in northern Wisconsin and northwestern Michigan. Current studies show that much of this loss is caused primarily by overmaturity of the timber and by drought conditions. This

study has therefore served as a basis for avoiding the possible expenditure of large sums of money for control work against an insect which is purely secondary in its attack.

(d) <u>Sucking insects which attack forest and shade trees</u>: Trees are subject to injury by many sucking insects, such as aphids and scales, that suck the juices from the leaves or other parts of the plant. Some of these insects cause additional injury by transmitting certain diseases of trees. Much is still to be learned concerning such insects and methods of controlling them. Present studies are centered at New Haven, Connecticut and Berkeley, California where particular emphasis is being placed on studies of the effects of certain scale insects on pines and the relationship of such injury to subsequent attack by bark beetles. Work is also being done at New Haven on measuring the electric potential of scale infested trees. It has been found that the electric potential of a tree varies directly with its vigor and it is probable that this may lead to the development of a method of measuring the relative vigor of individual trees and determining their susceptibility to attack by other insects, particularly borers and bark beetles. Thus, although this study was started as a phase of the work on scale insects, it may have wide application in studies of the physiological condition of trees as affecting their susceptibility to insect attack.

(e) <u>Insects attacking forest trees in nurseries, plantations, and areas of natural reproduction</u>: Forest reproduction, both in plantations and in natural areas and young trees in forest nurseries are attacked by many kinds of insects, both native and introduced. Such introduced insects as the European pine shoot moth and European pine sawfly; and native insects, such as white grubs, cut worms and various defoliators, cause extensive damage. With the extension of the CCC program and establishment of many large forest nurseries these problems have become increasingly acute. The CCC organization has planted more than two billion trees since 1933. This means that many thousands of acres of plantations are now reaching the stage where they are becoming increasingly susceptible to infestation and damage by insects. Plantations are nearly always more subject to insect damage than are stands of natural reproduction and this means that these trees must be given constant attention if the nation's tremendous investment in them is to be protected.

Only a limited amount of work is done each year on such pests as white grubs, white pine weevil, pales weevil, European pine shoot moth and sawflies, and there is much to be learned about these and other species in relation to the problem of protecting forests. Fairly satisfactory practical measures have been developed for use where the presence of the insects is recognized in time and the remedy is applied before damage is too far advanced. These investigations are being continued, chiefly with the idea of reducing costs, and a considerable amount of service work is given to the various CCC, Soil Conservation, and Forest Service nurseries.

(f) <u>The relation of climatic factors, such as heat, cold, moisture, etc., on forest insect populations</u>: For many years it has been recognized that weather and climatic conditions such as unusual low temperature and and drought affect the abundance of many different kinds of insects injurious to forest trees. In fact, at certain times these factors may be the controlling ones in developing conditions suitable for the build-up of epidemics.

Limited studies are being carried on at several of the western laboratories to determine the relation of climatic factors to the injury caused by various insects, particularly that caused by tree killing bark beetles. It has been determined that some of the destructive bark beetles are killed during periods of unusually low winter temperatures and thousands of dollars have been saved by stopping control operations in areas where these effective low temperatures have occurred. Much work remains to be done, however, in the study of climatic factors and their significance in building up and curtailing outbreaks of destructive insects and also in the practical application of this knowledge.

A detailed study of this kind was started at the Berkeley laboratory in 1939. Complete weather records are being taken at several points in the commercial pine area of northeastern California. The observation points are located in timber stands that are considered to represent four different degrees of hazard with respect to insect attack and the first year's records have already shown significant local differences in precipitation, air temperature and humidity, and the moisture content of the soil. Particular emphasis will be placed on the project for the next few years and it is believed that information will be obtained which will serve as a basis for predicting bark beetle outbreaks and thus enabling the timber owners to apply control or salvage operations with a minimum of actual loss.

(g) <u>Insecticides for the control of insects attacking forest and shade trees</u>: Insecticides can be used effectively and economically for the control of certain insects on shade and ornamental trees, and in some cases on forest stands of particularly high value such as mature timber or recreational areas. Studies are now under way to determine the dosage and materials most effective in controlling various kinds of insects attacking trees used for shade and ornamental purposes and limited studies are under way to develop new types of insecticides which can be economically applied to large forested areas either by the use of ground machines or by the use of various kinds of aircraft. During the past few years developments with the autogiro have indicated that insecticides can be applied by this means at one-half to one-third the cost of application by ground machines. An important phase of this work is the development and use of spray mixtures that are as much as 100 times more concentrated than are the spray mixtures ordinarily recommended. These concentrated mixtures contain only a small amount of water or other liquid and are therefore much cheaper to apply, especially by aircraft, because of the greatly reduced weight and volume. The use of these mixtures results in less waste of material, better coverage and better control as compared with conventional spraying methods.

(h) <u>Injection of chemicals into the sapstream of the tree for the control of bark beetle infestation and for the treatment of green trees to prevent insect attack upon the utilized wood</u>: Tree injection or the introduction of certain toxic chemicals into the sapstream of living trees in such a manner that they are readily distributed throughout all parts of the tree has been demonstrated to be thoroughly effective in preventing attack by various kinds of insects which feed on the bark and wood of nontreated trees. This makes it possible for farmers, particularly in the southeastern states where supplies of durable woods are lacking, to use fast growing cheap material, such as pine poles, for fence posts and other purposes where the wood is in contact with the soil.

Experiments now under way indicate that copper sulfate and zinc chloride are quite satisfactory for this purpose and cost but a few cents per post. The treated material now under test has lasted for 10 years while the checks were destroyed by insects and fungi within one year. A limited amount of work is under way at our laboratory at Asheville, North Carolina, to determine the possibilities of other chemicals and variations in the methods used, also to perfect the possible application of this technique to the control of bark beetle infestations. Some tests are also being conducted at the Morristown, Coeur d'Alene, and Berkeley laboratories.

(i) <u>Insects affecting forest products</u>: Forest products, including poles, posts, crossties, green logs and finished products, such as lumber, tool handles, etc., are attacked by a great variety of insects. The loss caused by such insects is estimated at 35 million dollars annually. A large part of this loss could be prevented by the use of chemicals or by making simple adjustments in the methods of manufacture or use.

Work is being conducted at several of the field laboratories to determine the most effective methods of preventing or controlling damage caused by insects which attack forest products. Ambrosia beetles are one of the most important groups of these insects and are being studied at the New Orleans and Portland laboratories. It has been found that proper timing of the cutting of logs in the woods and the sawing of lumber at the mill, so as not to have the green material exposed during the flight of the adult beetles, is effective in avoiding much of the infestation. Rapid seasoning of cut lumber to reduce the moisture content below 45 percent has also proven effective in the South. Many tests have been made with chemical sprays and dips but thus far no fully effective chemical has been found for this purpose.

Powder-post beetles are very destructive in seasoned lumber, articularly certain of the hardwoods. Experiments on their control are being conducted at New Orleans and Asheville and results thus far indicate that moisture and starch content of the wood are very important in determining the amount of damage to be expected from these insects. Certain modifications in the time of cutting and method of seasoning the

lumber will help to reduce the amount of infestation. The use of chemical sprays and dips, such as borax, sulphur, and other more complex chemicals has given satisfactory results in preliminary tests.

Timber that has been recently killed by fire or by windthrow is nearly always subject to prompt and severe infestation by various boring insects. The salvage of such timber before it has been damaged by these insects often constitutes a very serious problem. Studies of this type are being made under such conditions as those following the Tillamook Burn in Oregon where some 10 billion board feet of Douglas fir was killed in 1933 and where insect infestation was one of the most important factors limiting the salvage of this timber. Studies are also being made of insect conditions in forest stands that were damaged by the hurricane of 1938 in New England.

(j) Habits and development of methods for control of termites: Termites cause an annual loss estimated at 50 million dollars. With the present rapidly expanding building programs throughout the country and because of the lack of appreciation of the termite hazard, a large percentage of homes and other buildings are being constructed in such a manner as to be vulnerable to termite infestation. Previous study of this problem has resulted in the development of methods of control or prevention which are effective under certain conditions. Some of this information has been used by federal agencies and commercial companies. Some of the control or preventive procedures being used are of very questionable value and there is urgent need of further research to test the value of the various methods now being recommended and used to develop new or improved methods.

Present studies are being conducted at New Orleans, Asheville, Beltsville, Maryland, and in the Canal Zone. Much of this work is in cooperation with other Government agencies and also with commercial chemical companies and control operators. There is much work to be done in testing chemicals now in use and others that have been suggested for this purpose. The use of mechanical barriers or shields, as recommended by this Bureau, requires further work to develop more practical types and methods of installing them. Studies should also be made in cooperation with the building industry to develop simpler methods of building construction that will be effective in preventing infestation by termites. Adequate surveys should be made to obtain more specific information regarding the actual amount of infestation and damage by termites in various parts of the country and in buildings of various types of construction. One of the most pressing needs is to facilitate the dissemination of present information to the general public. Much of the present information given to the public by commercial agencies is of a type which causes undue alarm and often results in large expenditures by the private owners for work which is unnecessary.

(k) Value and use of introduced and native parasitic and predacious enemies upon introduced and native forest insects: Parasites and other natural enemies of forest insects contribute materially to the control of injurious species. Many different kinds of parasitic and

predacious insects have been introduced to aid in combating insects attacking forest trees, particularly introduced pests such as the gypsy moth, brown-tail moth, satin moth, and the European pine shoot moth. Studies to determine the value of these natural enemies in combating these introduced insects are being carried on at the laboratory at New Haven, Connecticut. This laboratory is also engaged in recolonizing various introduced and native parasites and predators which offer promise as aids in controlling injurious species.

(l) Importation of natural enemies of forest and shade tree insects: The most important work on this project at present is in efforts to establish introduced parasites of the European spruce sawfly throughout the area infested by the sawfly in the northeastern states. Very active cooperation with the states and with the Canadian entomologists is making it possible to make rapid progress in this work. About 20 million adults of one species of parasite were reared and liberated by the New Haven laboratory in 1939.

(m) Surveys to locate and determine the status of insect pests of the forests and the giving of advice to land managing agencies on planning and conducting necessary control work: Insect surveys, particularly of bark beetle infestations in the western states, constitute one of the most important activities under this appropriation. Land managing agencies, such as the Forest Service, National Park Service and the Office of Indian Affairs, as well as the private timber owners, depend upon the Bureau of Entomology and Plant Quarantine for advice on methods of controlling bark beetles and other forest insect pests and for planning the necessary control work. In order to give such advice, it is necessary to conduct surveys to determine the status of insect pests in the forest, locate areas of infestation and secure other information needed in planning control campaigns. In cases where control work is necessary the Bureau also gives technical assistance in organizing and conducting this work. After the control work is completed additional surveys are necessary to check on the results obtained and to determine whether or not further work is necessary in succeeding years. To make it possible to secure information as to the status of insects from as much of the tremendous area covered by forests as all available facilities will permit, forest rangers and others engaged in similar tasks are informed on various important pests and are expected to give aid in assembling information regarding the status of these pests in the forest areas under their supervision. The reports received from these sources are preliminary in character and before recommendations for control can be made, it is necessary to make more intensive surveys which can be used as a basis for control operations.

Most of this survey work is conducted at the western laboratories. For the past several years it has been possible to cover between 15 and 20 million acres annually, at a cost of $60,000 to $75,000. Part of this coverage has been in the nature of a very cursory reconnaissance and can be expected to result in the detection of only the more serious outbreaks. Many large areas have been given no attention.

As a result of research at the Berkeley and Portland laboratories, a method of classifying ponderosa pine trees as to their relative susceptibility to insect attack has been developed. One of the practical applications of this tree classification system is what has come to be known as the Hazard Inventory Survey conducted in the commercial pine area of northeastern California by the Berkeley laboratory. The field work is now practically completed on an area of over 3 million acres and the final report will show the forest areas as to relative hazard and the volume of timber in each risk class on each area. The Forest Service and several private companies who hold large bodies of timber in the area that has been surveyed are extremely interested in the results obtained and are making immediate use of the information as fast as it can be made available to them. They have revised their plans for logging operations and are now attempting to cover the parts of their holdings which the survey has indicated as being most hazardous. There is a strong demand to have this type of work extended into other areas in California and Oregon.

The reduction in the forest insect appropriation for the fiscal year 1941 has made it necessary to abandon the laboratory at Fort Collins, Colorado, and to curtail some of the survey work that has been conducted by the other western laboratories.

(n) Relation of insects to the Dutch elm disease: The Dutch elm disease, which is very destructive to our native elms, has been introduced from Europe and was first recognized in this country in 1935. The worst centers of infection are around New York City, including New Jersey, eastern Pennsylvania, southeastern New York and southwestern Connecticut. This disease is transmitted from tree to tree by certain bark beetles.

Studies are under way to gain more information regarding those insects known to transmit the disease and to determine whether others may also serve as carriers. In carrying out the eradication work, it is necessary to have definite information regarding the habits of the various insect vectors in order that these may be controlled and thus aid in checking the spread of the disease. Experiments are being conducted to obtain information regarding the flight range of the various insect carriers of the disease and to determine their distribution and the effectiveness of various methods of reducing their numbers. Sample plots have been established for studies of bark beetle populations following the application of control measures such as pruning out dead and dying parts of elm trees. Control of the beetles on other plots is being attempted by injecting sodium chlorate into a few elm trees scattered throughout the stand. It has been found that this chemical makes the trees especially attractive to the beetles and that treated trees can thus be used as traps. Additional work is needed to determine the actual effectiveness of this and other measures of reducing the beetle populations.

(o) Dissemination of information to the public on methods of controlling forest and shade tree insects, including general inquiries on this subject: Many thousands of inquiries are directed to the Washington and field offices regarding methods of controlling insects attacking forest and shade trees and forest products. The preparation of replies to these various inquiries is a part of the duties of all of the field laboratories and an important part of the work of the Washington office requiring the time of three employees stationed here. Some of these inquiries can be answered by means of Departmental publications but a large proportion of them require written replies in order to explain specific situations. The preparation of information for publication by the Department or by outside agencies and work on a moving picture film illustrating methods of termite control are other important activities under this project.

(k) BLISTER RUST CONTROL

The $400,000 appropriated under this head for the fiscal year 1941 is in the 1942 estimates transferred to and consolidated with the new item "White Pine Blister Rust Control", covering the work of the Bureau of Entomology, the Forest Service and the Interior Department.

(1) TRUCK CROP AND GARDEN INSECTS

Appropriation Act, 1941....................$366,580
Budget Estimate, 1942......................366,580

PROJECT STATEMENT

	1940	1941 (Estimated)	1942 (Estimated)
1. Truck crop insect investigations.....	$169,402	$170,413	$170,413
2. Berry insect investigations..........	5,847	5,877	5,877
3. Sugar beet leafhopper investigations.	72,890	73,390	73,390
4. Tobacco insect investigations........	88,550	73,900	73,900
5. Insects affecting greenhouses and ornamental plants....................	42,870	43,000	43,000
Unobligated balance....................	2,021	- - -	- - -
	381,580	366,580	366,580

WORK UNDER THIS APPROPRIATION

General: The work under this appropriation is concerned with the improvement of existing measures and the development of new and more effective ones for the control of insect pests of truck and garden crops, berries, sugar beets, tobacco, and greenhouse and ornamental plants. In these investigations particular emphasis must be placed upon the development of measures which will not involve residues harmful or undesirable to the ultimate consumer, and which will avoid the presence of insect fragments and evidence of injury in or on the portions to be marketed.

Project 1. Truck Crop Insect Investigations:

Objective: To develop against insect pests of vegetables satisfactory measures of control that will increase the growers' return by preventing losses in quantity and quality due to insects; and at the same time, safeguard the health of the consumer by eliminating the presence of harmful residues on the edible portions.

The Problem: During recent years the marked advances in efficiency of distribution have resulted in a substantial expansion in the year-around production of fresh and canned vegetables, especially by the development of the winter vegetable-producing industry in the South and in California. This increased production has tended, through the added competition, to decrease the margin of profit to the producer and the cost to the consumer. It has stimulated a demand by the consumer and producer for vegetables of higher quality, particularly as the quality is affected by the presence of insect damage and fragments.

The added competition and the greater demand for better quality products has emphasized the urgent need for development of adequate control programs against insects that will be economically feasible for use by the vegetable growers. Greater emphasis has been placed upon the harmful residue problem incident to the use of excessive quantities of arsenicals and other poisonous insecticides. This general situation has clearly shown the necessity for developing adequate control programs for insects injurious to the growing vegetables that will avoid the possibility of harmful residues on the marketed products.

Significance: Practically all of the principal vegetables are subject to attack each year by one or more species of insects. While it is difficult to estimate the actual losses suffered by the vegetable industry and home gardens from the depredations of these pests, it is believed that the losses can be estimated conservatively at 10 percent of the total value of the vegetable crops. Since the value of the commercially produced vegetable crops for the year 1933 was officially estimated at approximately $535,000,000, a 10 percent loss from insect attack would easily exceed an aggregate of $50,000,000. This shows the economic need for devising more effective methods of control of the insect pests attacking this class of crops, especially when it is realized that these losses resulted despite the fact that the control measures actually employed against these pests by the growers probably exceeded an amount estimated as $5,000,000.

Plan and Progress of Work: The following paragraphs discuss a number of activities conducted under this general project:

(a) Cole Crop Insect Investigations: The general course of investigations for cole crop insects includes (1) a study of the biologies of the various injurious species, with special reference to their habits, host plants, seasonal abundance, and other phases that may influence the formulation of programs of control for each destructive species, and (2) the development and practical testing as to effectiveness of adequate control measures, both cultural and insecticidal, with special reference to the avoidance of harmful residues on the market product.

Headquarters for these investigations are at Charleston, S. C., and Baton Rouge, La.

(b) Pepper Weevil Investigations: The general plan of investigations with the pepper weevil, a major pest of peppers in California, Texas, and New Mexico, has included (1) the obtaining of information on its biology that can be used in developing a satisfactory control program; (2) the promulgation and testing as to effectiveness in controlling the weevil by certain cultural practices; and (3) the development of adequate control measures by the use of insecticides, with special reference to the avoidance of harmful residues on the market product.

Headquarters for these investigations is at Alhambra, California.

(c) Lettuce Insects Investigations: The lettuce crop in Arizona and California of approximately 63,000 acres is severely damaged by the feeding of several species of caterpillars, particularly after the young plants are thinned. The production of lettuce seed is also affected by damage of a plant bug known as Corizus. The general plan of investigation under this project involves (1) biology studies of these insect pests with special reference to such habits as may have a bearing upon their control, and (2) the development of adequate measures of control of the pests, which will not injure the production and eliminate the possibility of harmful residues on the edible products. Headquarters for these investigations is at Phoenix, Arizona.

(d) Mexican Bean Beetle Investigations: The fundamental plan of investigation for the Mexican bean beetle consists of determining (1) its seasonal biology under Eastern conditions that may have a bearing upon its abundance and control, (2) the most effective insecticide to use against the insect in the field, with special reference to the avoidance of harmful residues on the harvested beans, and (3) the most effective insecticides for the combined control of other insect pests attacking beans in association with the Mexican bean beetle.

Sprays or dusts containing cryolite have been found to give good control of the beetle on snap beans, but this insecticide cannot be employed after the pods begin to form without the danger of harmful residues on the marketed beans. Experiments have shown, however, that satisfactory control of the beetle on snap beans in all stages of development can be obtained by the application of dusts or sprays containing rotenone, thus avoiding the possibility of harmful residues on the market product. Further studies are necessary to determine the most effective methods and schedules to follow in controlling the beetle on lima beans and other kinds of pole beans with the rotenone-bearing insecticides.

Recent observations and experiments have shown that different commercially prepared dusts containing approximately the same percentage of rotenone may not be equally effective in controlling the beetle when applied at the same rates and under the same conditions, thus indicating that the dust carriers used may influence the degree of effectiveness of the rotenone against the beetle. It is therefore essential that studies be undertaken to determine the effect of dust carriers upon the toxicity of rotenone to the beetle.

Headquarters for these investigations is at Norfolk, Virginia.

(e) Lima Bean Pod Borer Investigations: The plan of investigations for the lima bean pod borer on lima beans in southern California includes determinations of (1) those phases of its biology that may have a bearing upon the abundance and control of this pest, (2) the status of its natural enemies and the possibility of achieving control of the pod borer by introducing and disseminating such enemies, and (3) the utility of insecticides and cultural practices in controlling the insect.

Headquarters for these investigations is at Ventura, California.

(f) Wireworm Investigations in Irrigated Lands: The general plan of investigations for the principal species of wireworms attacking truck and vegetable crops in irrigated lands of the Pacific Northwest and in California include observations and experiments relating to (1) those phases of the biologies as may be required to devise effective control measures for these pests. (2) the effectiveness of various cultural practices in their control, such as drying or flooding of infested areas, varying the time of planting and use of crop rotation, (3) the effectiveness of natural means of control such as the dissemination of diseases among the wireworms, and (4) the effectiveness of controlling these pests by the use of trap crops, insecticides, and a combination of the two methods.

Much valuable information on the biologies of the three most detrimental species of wireworms in irrigated lands of the West has been obtained which will assist materially in the promulgation and testing the effectiveness of control measures against these pests. Fairly effective control of wireworms has been obtained by withholding the irrigation water during the early part of the growing season for a period of three or four years, when the land is well drained and growing upon it a deep-rooted crop, such as alfalfa. It has been found, also, that a very large percentage of the wireworm infestation can be killed by flooding infested fields with water for a period of five to seven days when the temperature of the flooded soil is at or above approximately 70° F.

Varying the time for planting certain crops, with respect to the life cycle and seasonal abundance of the wireworms, has been of material assistance in lessening the ravages of these pests. Intensive studies have also resulted in demonstrating that by following certain systems of crop rotation the infestation and damage by wireworms can be materially lessened.

Intensive studies over several years showed that while large numbers of wireworm adults could be attracted to and trapped in piles of certain plants placed about over a field, there was no ultimate reduction of wireworm infestation or injury either in the field containing the traps or in adjacent fields. Effective reduction in numbers of wireworms and in their injury to germinating plants has been achieved by applying an insecticide, such as calcium cyanide, to the soil beside rows containing a bait, such as cracked beans, after the wireworms have been attracted to the bait. This method of control is applied before the seed-planting time.

Of the large numbers of stomach poisons, contact insecticides, and soil fumigants tested against the wireworms over a period of years, only a few that are practical to use have shown promise of being effective and none has proved applicable under all conditions. For instance, on sandier types of loam soils, the application of crude naphthalene in a specified manner gives fair control of the wireworms

in the Pacific Northwest. Chloropicrin, while very toxic to wireworms, was too expensive for practical application in the irrigation water in California. Dichloroethyl ether also proved highly toxic to wireworms, but when applied at effective rates caused damage to some of the plants. Recent experiments have uncovered several other compounds which show exceptional possibilities in controlling these pests, but the tests are only in the initial stages. By way of summary it can be said, therefore, that while many possibilities for controlling wireworms in irrigated lands of the West have been explored, none of them has been entirely effective or applicable under all conditions.

Headquarters for these investigations are at Parma, Idaho, Ventura, California, and Walla Walla, Washington.

(g) Gulf Wireworm Investigations: Studies with the gulf wireworm are directed toward (1) obtaining information on the biology of this insect that may have a direct bearing upon its control, and (2) determining the effect of crop rotations, destruction of the wireworm adults, and soil fumigants in the control of the gulf wireworm. Headquarters for these investigations is at Sunset, Louisiana.

(h) Sweetpotato Weevil Investigations: The general plan of investigation with the sweetpotato weevil includes (1) obtaining such information upon its biology as may have a direct bearing upon the control of this pest, (2) information on the possibility of eliminating the weevil by clean-up operations, and (3) the effect of a combination of various control measures upon the weevil population, such as restricting the number of infested sweetpotatoes or portions thereof by quarantine regulations, clean-up and cultural practices, fumigation of seed sweetpotatoes, and the application of insecticides.

These studies have shown that while the sweetpotato is the principal host plant of the weevil, it also feeds and breeds commonly on several closely related wild plants belonging to the morning-glory family, viz., *Ipomoea pescaprae*, *I. littoralis*, *I. pandurata*, and several others. Although the principal medium of long-distance weevil dissemination is by transportation of weevil-infested sweetpotatoes and sweetpotato plants, it has recently been found that marked weevils were caught in light traps as much as 1 1/4 miles from the point of liberation. Biology studies have also shown that the weevil without food can live as long as 28 days during the summer, and 144 days during the winter. The adult weevils emerged from cleaned potato fields for slightly more than one month following the clean-up work; and they continued to emerge for several months from sweetpotato crowns left in the field, although the bulk of emergence occurred during the first 30 days following harvest. The adult weevils emerged throughout the winter from sweetpotatoes exposed to all winter freezes as well as from those covered with soil. Emphasis should continue to be placed upon the biology of this pest to gain more information that can be used in developing a satisfactory control of the weevil.

An extensive clean-up campaign directed against the wild host plants of the weevil showed that the population on these plants could be reduced remarkably, removing temporarily at least, the wild host breeding source of the weevil. Other methods of reducing weevil infestation and damage that have been discovered include fumigation of the seed potatoes, the propagation of the crop from vine cuttings, covering the potatoes deeply in sandy types of soil, which renders them less accessible to weevils for egg laying, a rotation of crops so as to avoid the planting of sweetpotatoes on the same land for two or more succeeding years, the destruction of plant remnants in seed beds and in the field after harvest, and a clean-up of storage banks and storage houses.

Other experiments have shown that the application of calcium arsenate at intervals of two weeks throughout the season gave very good protection to the potato vines but it was not very effective in protecting the developing roots from weevil damage. Recent studies indicate promising possibilities by using a poisoned bait consisting of grated sweetpotatoes 20 parts and paris green 1 part. Further experiments should be conducted to develop an effective poisoned bait for (1) measuring populations of the sweetpotato weevil, (2) determining by its use the effectiveness of eradication measures being carried out, and (3) the effectiveness of the bait for controlling the weevil on a commercial basis.

Headquarters for these investigations is at Sunset, Louisiana.

(i) Pea Weevil Investigations: The plan of the investigations with the pea weevil include (1) studies to obtain such information on the biology of this pest as may have a direct bearing upon its control (2) observations to learn the status of native natural enemies of the pea weevil and efforts to introduce natural enemies from Europe or other available areas, (3) the effects of various cultural practices upon the control of the weevil, and (4) the possibility of utilizing insecticides in the control of the weevil.

Biology studies with the pea weevil disclosed that it attacks the green seeds and cannot reproduce in dried seed; that the insect hibernates successfully in practically every situation affording some degree of protection from the elements; that the adult weevils begin flights in the spring time when daily maximum temperature reach 66°F. to 74° F., the number of weevils that fly depending upon the temperature, time of day, and season; that the pea weevils have a tendency to stop at the first blossoming peas when they are in flight from hibernation quarters to fields; that the loss of weight and vitality of weevil-infested peas is correlated with the development of the pea weevil and the time when egg-laying occurred; and that infested peas shattered in the field prior to or during harvest, volunteer peas, stored pea hay containing peas and seed peas, constitute the principal sources from which weevils emerge and infest the next crop. Further studies should be made to obtain additional information upon the biology of the weevil as may assist in devising more effective measures for the control of this pest.

Although two native species of insect parasites were found attacking the pea weevil in Idaho, they are present in limited numbers and do not exert an important degree of natural control. Large numbers of another parasitic insect were imported from Europe and liberated in the Moscow, Idaho, district.

Field observations and experiments have shown that it is extremely important to destroy all crop remnants or shattered peas, preferably by plowing under as soon as harvest is complete, that although in general the pasturing of harvested pea fields with livestock has proved to be unsatisfactory as a sole method of controlling the weevil in shattered peas, this method can be used under some circumstances as a supplementary measure prior to clean and deep plowing of the harvest debris and other plant material in the field, that the use of an early planted strip of peas around the edges of large pea fields function as a trap crop and that the control of the weevils on the trap plants by use of a rotenone-bearing dust serves as an important aid in the control of the pests.

Extensive observations and experiments have shown that only weevil-free seed should be planted since large numbers of weevils are able to escape from infested seed and act as an important source of infestation for the growing crop that early harvesting is an important factor in the control of the pea weevil in seed peas that the fumigation of infested seed peas with several fumigants is an effective means of preventing damage by the weevil to the seed peas and to the future crops in areas where such seed will be planted, that particularly in the instance of Austrian winter field peas, fumigation should be as soon as possible after harvest so as to kill any weevil larvae before they affect germination; that it was possible to separate sound and undamaged seed peas from those infested by the weevil by use of a flotation method in a salt solution; that the application of dust mixtures containing rotenone to weevil-infested fields or portions thereof resulted in a very high degree of control of the pest; that weevils become less resistant to dust mixtures containing rotenone the longer they remain in hibernation; and that the particle size of the carrier, type of carrier; and root source of rotenone, affect the toxicity of the dust mixtures containing rotenone to the pea weevil. Further studies should be conducted with rotenone-bearing insecticides in the control of the weevil to test its value for controlling the weevil under a wide variety of weather and seasonal conditions; to determine the most effective program of dusting to follow, with respect to the time and frequency of dusting, the effectiveness of utilizing and treating trap crops or borders of fields, the most effective particle size and type of carrier and the root source of rotenone that can be used in preparing the insecticide to be used, and other factors which might increase the effectiveness of the insecticide used, and at the same time decrease the cost to the grower.

Headquarters for these investigations are at Moscow, Idaho, and Forest Grove, Oregon.

(j) Investigations of Natural Enemies of the European Earwig: The general plan of this investigation includes (1) obtaining information on the biologies of the European earwig parasites Bigonicheta setipennis, Rhacodineura antiqua, and other available parasites that will assist in their rearing, liberation, and successful establishment in the field; (2) developing efficient methods for rearing the parasite; (3) obtaining information upon their abundance and natural spread of the parasites after they have been liberated in the field under widely divergent environmental conditions; and (4) obtaining information upon the time that application of the standard earwig bait may be made in various localities requiring immediate relief from the earwig with least effect upon the natural increase of parasite populations.

Efficient methods of rearing B. setipennis and recovering them in the field have been developed. Considerable numbers of this parasite have been liberated in approximately 20 localities in the Pacific Northwest and at other points in the East, altogether including the States of Washington, Idaho, Utah, Massachusetts, Rhode Island, and Connecticut. Parasitized earwigs also have been liberated in several places. Detailed investigations by the use of traps have shown that this parasite is becoming established in some of the localities. In the vicinity of Puyallup, Washington, the area occupied by the parasite showed an increase of 15 square miles in 1939 over the 105 that it occupied in 1938. The establishment,.spread, and general effectiveness of this parasite should be closely followed from a quantitative standpoint, and efforts should be made to develop satisfactory procedures for determining this point.

The liberation and establishment of the other parasite R. antiqua has recently begun, the method used being that of mixing the parasite eggs with food of the earwig and placing the infested food in places where it will likely be consumed by the earwigs. Further studies should be conducted to determine the effectiveness of this method of liberation, to develop other methods, and to determine the degree of success in its becoming established in different places.

Headquarters for these investigations is at Puayllup, Washington.

(k) Tomato Insects Investigations: The plan of investigation includes observations and experiments (1) for obtaining such information on the biologies of insects attacking tomatoes as may be pertinent to the successful development and application of measures for their control, and (2) for developing effective control measures, including those of employing traps for the adults, poisoned baits for the adults and immature stages, and of applying insecticides to the plants for the control of insects injurious to tomatoes, with special reference to the avoidance of harmful residues on the marketed tomatoes and of damaging the developing plants. These investigations have been directed chiefly toward the tomato fruitworm and the tomato pinworm.

Intensive experiments with insecticides have shown that fairly effective control of the tomato fruitworm can be obtained from the application of calcium arsenate dust or of a dust mixture containing a high percentage of cryolite. While both of these insecticides involve residue hazards, it has been found that by using a dry cloth a major portion of the insecticidal residues can be wiped from fruit thus treated under California conditions. The application of a poisoned bait consisting of corn meal and cryolite has also shown promise of giving fairly effective control of the fruitworm on tomatoes. Some progress has been made in developing light traps and bait traps for catching the adult moths. Further experimentation is needed to determine (1) which of three insecticidal treatments is most effective against the tomato fruitworm in various sections of the United States, (2) whether more effective insecticides can be developed, which will entirely avoid the residue hazard, and (3) the most effective program or schedule for applying control measures under varying seasonal conditions and in the different tomato-producing districts of the country.

Extensive experiments have shown that the application of cryolite and cuprous cyanide dusts are the only known materials to give effective control of the pinworm. While these materials are effective for a short time after application, the population of the pinworm soon builds up during the fruit-picking season when the use of such poisonous insecticides causes a harmful residue on the fruit. Additional work is necessary (1) to develop a suitable insecticide for control of the pinworm during the picking season, (2) to determine the most effective dilutions of the cryolite and cuprous cyanide dusts, and (3) to obtain other information respecting the most effective rates of application and the most effective treatment schedule.

Headquarters for these investigations are at Alhambra, California, Logan, Utah, and Columbus, Ohio.

(l) Importation of Natural Enemies of Insects Attacking Truck Crops: These investigations are administered by the Division of Foreign Parasite Introduction, Bureau of Entomology and Plant Quarantine, as indicated in the discussion on the work program under the appropriation for Foreign Parasites.

(m) Vegetable-Insecticidal Investigations: The general plan of work of this project includes (1) field and laboratory experiments with various insecticides, in various forms and combinations, against several of the more common insects and related forms attacking vegetables in the Central States, such as the eggplant lacebug, potato stalk borer, potato beetle, harlequin bug, cucumber beetle and Mexican bean beetle, with special reference to the relative toxicity of these insecticides, or combinations thereof, to the insects and to the plants and the avoidance of objectionable residues on the market product; (2) tests to determine the insecticidal value of the newly patented insecticide sulfur nitride, and other new insecticides which it seems desirable to test, against a wide range of insects and related forms attacking vegetable crops, and when necessary to conduct tests looking toward the improvement of their physical properties as insecticides;

and (3) a determination of the insecticidal value of certain new compounds belonging to the azo-benzene group. Headquarters for these investigations is at Columbus, Ohio.

(n) Investigations on Red Spiders and Thrips Attacking Vegetables. The plan for this investigation is to determine (1) the nature of damage caused to vegetables by red spiders and thrips, with special reference to any relationship between thrips and blossom drop; (2) the seasonal abundance and local distribution of red spiders and thrips on vegetables; and (3) the possible use of the newer materials as a control for red spiders and thrips. Headquarters for these investigations is at Sanford, Florida.

(o) Investigation of Potato Psyllid: The general plan of this investigation is to ascertain the factors responsible for outbreaks of the potato psyllid on the Eastern Slope and Mid-Western States. Efforts will also be made to correlate with control operations against the psyllid those factors affecting its movement from wild host plants to the cultivated areas. Headquarters for these investigations, begun in 1939, is at Scottsbluff, Nebraska.

(p) Investigations of Aphids Affecting Vegetables: The plan of this investigation includes a determination of the biologies of aphids attacking vegetables with special reference to those phases that have a direct bearing upon their abundance and control; the relative effectiveness against aphids of various insecticides applied as dust, sprays, and in a vaporized form; and the influence upon the residual toxic effect of different insecticides of temperature, precipitation, relative humidity, and wind velocity.

Although such investigations have recently begun with aphids attacking potatoes in Maine, the efforts of this project have been confined essentially to the pea aphid in Wisconsin. In the instance of the pea aphid, biology studies have indicated that the severity of infestation and damage by this pest are determined by several factors, including soil fertility, temperature and rainfall during the period of crop growth, the abundance of natural enemies, and the abundance of the aphid during the spring in nearby fields of alfalfa or clover, which serve as principal sources of initial infestations of aphids on peas.

Effective control of this pest on peas in Wisconsin can be expected under certain conditions by the application of dusts or sprays containing rotenone, by dusts containing nicotine, or by vaporizing nicotine. To be adequate, application should be thorough and properly timed. The thoroughness of application, while varying for the different kinds of treatments, has been found to be influenced by the machinery used, the temperature, wind velocity, relative humidity, and wetness of the foliage. Although the best time to begin treatments has not been definitely determined, the evidence obtained indicates that they should begin when an average of 35 aphids per sweep of a standard insect net is found by counting the aphids taken from samples of 5 sweeps each made on the plants at different places over the field. The effectiveness of the treatments is also influenced by weather conditions after application.

Headquarters for these investigations are at Madison, Wisconsin, and Houlton, Maine.

Project 2. Berry Insects Investigations.

Objective: To discover measures suitable for the control of insect pests of berries that will (1) increase the quality and quantity of fruit produced, (2) increase the return to the producer, and (3) safeguard the health of the consumer from the presence of harmful residues on the edible berries.

The Problem: The berry crops, which include strawberries, raspberries, blackberries, loganberries and youngberries have a series of stages in the period of growth and maturation of fruit which require constant and intensive care usually during only a short period of each year. Similarly, most of the insects vitally affecting the production of berries confine their injuries to a short period and to specific portions of the plant. The solution to this problem involves (1) the development of measures, both insecticidal and cultural, that can be thoroughly enough applied to control the insects effectively on or in even the most inaccessible portions of the plant, and yet cause no injury to the youngest and tenderest parts, or cause no reduction in yield; and (2) the development of insecticidal measures satisfactory for applying to the tender developing berries that will protect them from insect damage and leave no harmful residues.

Significance: The total value of the commercially grown strawberry, raspberry, blackberry, loganberry, and youngberry crops which are affected by the insects under this project totaled approximately $53,000,000 during 1933, according to official estimates. Although damage by the insect pests attacking these crops varies from season to season, it is estimated that, on the average, an aggregate loss equivalent to 25 percent of the value of the enumerated berry crops is sustained from this cause each year by the commercial growers, to which must be added an undetermined loss by the many home gardeners growing these crops. It is conservatively estimated that the raspberry fruitworm alone causes an annual loss of at least $3,000,000.

Plan and Progress of Work:

(a) Raspberry Fruitworm Investigations: The plan of work under this project includes a determination of (1) the distribution and biology of the raspberry fruitworm, particular emphasis being placed upon any discoveries that might have a bearing upon its control, and (2) control measures by insecticides or other methods that will be commercially feasible and will avoid the possibility of harmful residues on the market product.

The general distribution, principal features in the biology and satisfactory control by insecticides of the raspberry fruitworm on raspberries has been accomplished. The control consists of applying to the raspberries at regular intervals during the fruit season

dust or spray mixtures containing rotenone, any residues from either not being harmful. While some additional studies are being made to determine the most effective program for application of insecticides, it is expected that this project can be terminated after an additional year's investigation.

Headquarters for these investigations is at Puyallup, Washington.

(b) Red Berry Mite Investigations. The work under this project concerns a determination of (1) information on those phases in the biology of the red berry mite that may have a bearing upon its control, and (2) a satisfactory control program for this pest on the evergreen blackberry that will avoid the presence of harmful residues on the market product.

Headquarters for these investigations is at Puyallup, Washington.

Project 3. Investigations on Insects Attacking Sugar Beets.

Objective. To develop suppressive and control measures for insects that annually infest the sugar beet crop, particularly the beet leafhopper in the Western States.

The Problem: With the development of reclamation projects and the irrigation of desert lands in the Great Basin area and in California, Texas, New Mexico, Arizona, Oregon, Washington, and Montana, the cultivated crops were exposed to a native insect known as the beet leafhopper. This leafhopper fed naturally on sage brush, which is not a favorable host, nor are the grasses which originally covered the lands in these semi-arid regions. However, with the denudation of the grass lands through over grazing and ill advised breaking of the land, introduced weeds gained a foothold and these weeds, especially the Russian thistle and the mustards, proved to be very suitable plants upon which the leafhopper could thrive and multiply in enormous numbers and spread to the comparatively small cultivated areas. Sugar beets, beans, tomatoes, and other vegetable crops are seriously affected by the beet leafhopper as they are very susceptible to a disease known as curly-top, which is carried by the leafhopper from an infected plant to a healthy one.

Because of this disease factor the control consists of preventing the leafhopper from infecting the plants with the curly top disease, and, considering that one leafhopper may infect several plants within a short time, and its movement from the desert to the cultivated crop occurs over an extended period, it is difficult to protect a crop by spraying. Consequently, the problem becomes one of (a) the development of plants resistant to leafhopper attack or to the disease; (b) the elimination of wild breeding areas; (c) the timing of crop planting so as to avoid heavy infestation by the insect; (d) establishment of trap crops in the vicinity of the cultivated areas so that these trap crops would receive the main impact of the leafhopper migration;

and (e) development of chemicals which when applied to the crop will serve as repellents over the entire period when infection will be most critical.

Beside the beet leafhopper there are several other insects, such as the beet armyworm, flea beetles, cutworms, root maggots, and plant bugs which affect the sugar beet crop. In recent years the plant bugs have become of particular importance in the areas which are being devoted to the production of beet seed.

Significance: In 1938 the sugar beet acreage in the States where the leafhopper occurs was 553,000 acres and on the basis of the price for beet sugar for 1937 amounts to an income of approximately $40,500,000. Prior to the development and use of varieties of sugar beets resistant to the curly-top diseases, the losses were so severe that beet culture was abandoned in some areas and in other areas the industry was very unstable. Even with the planting of resistant strains of beets, losses caused by the insect, while not so severe as formerly, are still a decided factor in the successful production of sugar beets, especially during the years when the migration of the leafhopper takes place when the beet plantings are small. Crops such as tomatoes and beans are annually subject to serious losses, and the production of varieties of bean seed to supply the demand for the country as a whole is at the best always attended by considerable hazard.

The production of sugar beet seed in this country is practically in its infancy and will become more important if the supply of beet seed from Europe is cut off because of war conditions. In recent years the resistant types of beet seed have been produced on a large scale. In 1938 approximately 14,000,000 pounds of beet seed was harvested from a little more than 8,000 acres and about half of this was of the resistant type grown from nearly 3,000 acres. The vast majority of this seed acreage is subject to injury by the leafhopper and by certain kinds of plant bugs, the latter attacking the seed stalks and seed pods and besides reducing yields affects adversely the germination or viability of the seed.

Plan and Progress of Work: Investigations under this financial project are divided into three work projects (a) Sugar beet leafhopper investigations in intermountain region with headquarters in southern Idaho (Twin Falls); (b) sugar beet leafhopper investigations in California with headquarters in the San Joaquin Valley (Modesto); and (c) insects affecting seed beets with headquarters in southern Arizona (Phoenix).

(a) Sugar Beet Leafhopper Investigations in Intermountain Region: In general the plan of these investigations is to study closely the leafhopper in its desert and cultivated habitats, in order to develop measures to prevent the insects from transmitting the curly-top disease to sugar beets, beans, tomatoes, and other vegetables. This work involves (1) locating the breeding areas and determining the density of the host plants which occur in such areas together with a study of

those phases of the insect's habits and seasonal development which influence the magnitude and time of movement of the pest from the wild breeding areas to the cultivated crops; (2) to determine the possibility of minimizing the leafhopper losses by the elimination of important breeding areas through the promotion of the growth of native grasses by proper range and desert land management; (3) to explore the possibilities of developing a sugar beet or other plants upon which the leafhopper cannot breed and infect with the curly-top disease; and (4) to conduct laboratory and field tests with new chemical combinations as a possible means of developing a material which can be used on the cultivated crop as a repellent during the critical stage of the crop's development.

Headquarters for this investigation is at Twin Falls, Idaho.

(b) Beet Leafhopper Investigations in California: In general the plan of these investigations includes (1) the determination and location of important breeding areas of the beet leafhopper, (2) biological studies of the leafhopper and its natural enemies, and (3) studies to determine the possibility of eliminating breeding areas of the insect through range management and the direct destruction of weed hosts in the cultivated areas and also the killing of the leafhoppers by chemical treatment during the spring and fall in the uncultivated breeding areas. It has been determined that the principal sources of infestation of the beet leafhoppers are in the foothills of the San Joaquin Valley and that the insects move from these foothills into the cultivated areas of the Valley and northward into the Sacramento Valley. During the fall and winter period the leafhoppers move from the cultivated areas back to the foothills where they are concentrated on a comparatively small weedy area. With the development of this information sugar companies operating in these Valleys inaugurated a spray program designed to destroy the leafhopper in its winter quarters, and while the actual benefits in yields of sugar beets per acre is difficult to measure, it has been conservatively estimated that from one-half to two-thirds of these winter leafhopper populations have been destroyed by this treatment and that the leafhopper populations in the Sacramento Valley have consistently remained at a low level and the yield of beets has increased. Tomatoes have also been planted in areas formerly regarded as unsafe for tomato culture. In the San Joaquin Valley the populations have been such that the growers have attempted to reestablish the growing of beets in certain sections of this Valley. In conjunction with the spraying the commercial interests have also undertaken the elimination of weedy areas by mechanical means. The attempt to control an insect of this kind outside of the cultivated areas is a comparatively new departure in insect control and it will be several years before the exact value of this type of control is definitely established.

Headquarters for these investigations is at Modesto, California.

(c) Insects Affecting Seed Beets: The general plan of these investigations is to determine through a detailed study (1) to develop the identity and relative abundance and economic status of certain

plant bugs which are prevalent in the sugar beet seed producing districts of Arizona, New Mexico, California, southern Utah, and Nevada; (2) to develop an effective chemical control for these insects which will prove to be of economic importance; (3) to determine the economic value of treating beets grown for seed with pyrethrum-oil sprays as a control for the beet leafhopper.

The results of these studies show that the seed beet crop treated with pyrethrum-oil for beet leafhopper control has indicated significant increases in the yield of beet seed and that the treated beets yielded seed which produced a higher germination than the untreated seed. The increase in yield in the experimental plots on season was 31.7 percent for one treatment and 60.2 percent for plots treated twice, and the treated plots showed an increase of 4.6 percent higher germination of seed. In one instance the protection afforded by the treatment yielded an equivalent of $30 increase in return per acre for the seed.

Headquarters for these investigations is at Phoenix, Arizona.

Project 4. Tobacco Insect Investigations:

Objective: To improve existing measures and to develop new and more effective ones against insect pests of tobacco in the field and in storage, and to devise satisfactory measures for the suppression of those insect pests of tobacco about which little is known, with special reference to the development of measures that will control the pests at a minimum of cost and leave no harmful insecticidal residues on the market product.

The Problem: The production of tobacco and tobacco products are highly specialized industries. During its growth tobacco passes through a rapidly changing series of stages, all of which are susceptible to severe ravages by insects. During most of these stages the insect attacks not only affect the quantity and quality of leaf production but the very life of the plant itself is at stake. The unavoidable complications arising from the nature of growth of the plant and the highly specialized cultural processes involved in production, make very difficult the development of satisfactory measures for the control of the many serious pests. These difficulties are further enhanced by the developing and mature leaves being usually susceptible to injury by many insecticides, influencing both quality and quantity of production. There is no possibility of removing harmful insecticidal residues from the tobacco which were present at harvest or applied to the leaves at any time during the long period of storage prior to manufacture. Since the leaves of growing and of stored tobaccos possess high adsorptive and retentive qualities for certain chemicals especial care must also be exercised to avoid the application of insecticides which might impart an undesirable aroma or quality to the manufactured products. The tobacco is kept tightly packed in piles, hogsheads, and bales, making very difficult the effective application of insecticides which must be used to prevent heavy losses from pests which attack the tobacco during storage in growers' pack houses and in storage warehouses.

Significance: Tobacco is one of the most important crops grown in the United States, being grown extensively on a commercial scale in approximately 20 States, most of which are east of the Mississippi River. In 1937 the last year for which complete data are available, there was a total production of approximately one and one-half billion pounds that brought a total income of $318,305,000 to the growers. For that year the production and value by types were as follows:

Types	Pounds	Value
Flue-cured	854,833,896	$196,718,000
Burley	419,006,649	78,326,000
Cigar leaf	105,066,000	18,967,000
Fire-cured	116,548,813	12,077,000
Maryland	22,750,000	7,810,000
Dark-air-cured	46,515,175	4,407,000
Totals	1,564,720,533	$318,305,000

The total value of all stored domestic and imported tobaccos present in this country during 1931 reached a total of approximately $1,155,851,000.

A number of insect pests exact tolls from all stages in the growth and storage of tobacco. While the amounts exacted vary each year, a conservative estimate is that 20 percent of the potential value of the crop is lost annually through the ravages of these insects to the growing crop. The loss in stored tobacco prior to 1931 was estimated at about $7,000,000 per year. Since that time the application of control measures has been so vigorously pursued that in 1936 the loss from such insect damage was estimated at $3,235,000.

Plan and Progress of Work:

(a) Insects Attacking Field Grown Tobacco in Dark Fire-Cured Area: The plan under this work project is to conduct experiments (1) to obtain information on the biologies of hornworms, flea beetles, sod webworms, slugs, and other insects attacking field grown tobacco in the dark fire-cured area which might have a direct or indirect bearing upon the control of these pests; and (2) to develop insecticidal, cultural, or control measures against these pests suitable for commercial use, with special reference to the avoidance of harmful residues to the growing plant or on the marketable product.

Effective progress has been made in developing a trap in which the hornworm moths are held until they die after eating a poisoned bait, thus preventing egg laying on tobacco. Further work in developing both the trap and the poisoned bait is necessary before this method of control will be commercially feasible. The use of dusts and sprays containing lead arsenate for the control of hornworms was discovered, but after the growers had successfully employed this method the recommendation had to be withdrawn because of the undesirable and harmful residues of lead and arsenic on the cured tobacco. Progress is now

being made in the effort to evolve a satisfactory substitute for compounds containing lead or arsenic. Although not entirely complying with all requirements, with respect to harmful ingredients, cryolite has shown considerable promise for use as a temporary substitute for the arsenical compounds in the control of hornworms.

Sprays or dusts containing lead arsenate or lead arsenate and paris green were found to control satisfactorily the tobacco flea beetle in plant beds, on newly set plants, and on the tobacco growing in the field. Dust mixtures containing 1 percent of rotenone were also found to be very effective against the beetle when applied at any stage of growth of the tobacco. Since this insecticide has little residual toxicity for the beetle, and since other beetles soon move into a field thus treated, further studies are required to develop a control for the beetle that will be feasible for commercial use.

Headquarters for these investigations is at Clarksville, Tennessee.

(b) Insects Attacking Field Grown Tobacco in Flue-Cured Area: The investigations under this work project have for their principal objectives the determination of (1) those phases of the biology of the tobacco flea beetle, tobacco hornworms, wireworms, green June beetle larvae, and other insects attacking field grown tobacco in the flue-cured area that may have a direct or indirect bearing upon the control of the pests; and (2) the most effective insecticides and cultural practices to use in the practical field control of these insects, with particular reference to the avoidance of harmful or objectionable residues on the marketed product and the effect of such treatments upon the plant. Although considerable progress towards the satisfactory solution of these problems has been made by the following indicated lines of endeavor, there remains much to be solved.

Intensive studies indicate the possibility of introducing some cultural practices during the fall or winter which might reduce overwintering populations of the tobacco flea beetle, since it has been found that large numbers of the beetle pass the winter in the environs of old undisturbed fields of tobacco, in grassland bordering such fields, and in the edge of woods. Tobacco has been found to be the essential plant on which the beetle breeds and multiplies, recent studies indicating that the prevention of breeding in tobacco plant beds may be an important possibility for reducing the numbers and injury on tobacco growing in the field. Excellent protection of newly set tobacco from injury by the beetle has been obtained by the application of insecticides to the plants immediately before or after transplanting. Although the application of rotenone-bearing insecticides effects high percentages of beetle mortality on field tobacco, it has been observed that other beetles soon move into the treated fields. The use of this insecticide, while involving no harmful residue, is thus not entirely satisfactory at present for commercial control of the beetle in the field.

Intensive studies have indicated that sprays and dusts containing high percentages of cryolite are effective in the control of hornworms on tobacco, although the dust at present does not possess qualities entirely suitable for this method of application. Substitution of cryolite for the commonly used insecticide, lead arsenate, will eliminate the undesirable residues of lead and arsenic, but a further search should be made to discover an insecticide for the control of hornworms which will leave no harmful residue on the cured leaves.

Although injury by wireworms constitutes a problem of major importance on newly set tobacco over much of the flue-cured area, it has been possible thus far to perform few experiments looking toward their control.

The poisoned bait developed for the control of Green June beetle larvae in tobacco plant beds has been found not to be very effective against this pest in the flue-cured area and experiments are now in progress to discover a more effective means of controlling this important pest.

Headquarters for these investigations are at Oxford, North Carolina, and Florence, South Carolina.

(c) Insects Attacking Shade-Grown Tobacco: This work schedule includes observations and experiments on the biology of the tomato worm, flea beetles, the budworm, mole crickets, the vegetable weevil, thrips, cutworms, grasshoppers, and wireworms in areas growing cigar-type tobaccos, to gain information which might have a direct or indirect bearing upon the control of these pests. Intensive experiments have been conducted or are now in progress to develop insecticidal and cultural measures adequate for commercial control of these pests, which special reference to the avoidance of harmful residues on the market product or direct injury to the developing plant.

Biology studies have shown that the destruction of tobacco stalks soon after harvest, together with deep fall or winter plowing do much to reduce overwintering populations of the hornworm. While the use of lead arsenate or of paris green has given excellent control of this insect on cigar tobacco, the application of these insecticides has proved to be objectionable from the standpoint of possible injury to the plants and of leaving undesirable residues on the marketable leaves. Dust mixtures containing cryolite have given promise of being effective in controlling the hornworms, but further work is required to develop an adequate control for this pest.

Headquarters for these investigations are at Quincy, Florida, and Windsor, Connecticut.

(d) Insects Affecting Tobacco in Storage; The general plan of work includes (1) a study of the biologies of the cigarette beetle, the tobacco moth, and their parasites and predators, with special

reference to any factors which might have a bearing upon the control of these two pests; (2) experiments to develop satisfactory fumigants, and the most effective means for their application against the two pests under conditions of open and closed storage warehouses; and (3) experiments to develop satisfactory methods for the control of the tobacco moth on tobacco in growers' pack houses.

Excellent progress has been made in developing effective methods of applying fumigants in the control of the cigarette beetle and tobacco moth in closed storage. However, the continued losses from the ravages of these insects warrants further studies to discover means of more effective control. Some progress has been made leading toward the control of these insects in open storages but much additional work on this project is necessary. The use of fumigants is complicated by the nature of the open storage warehouses, and the use of insecticidal dusts has proved to be inadequate as well as from the standpoint of leaving objectionable residues. An efficient suction light trap has been developed and used to considerable advantage in catching the cigarette beetle and tobacco moth both in open and closed storage warehouses. Experiments are in their initial stages for the control of the tobacco moth in pack houses of tobacco growers and much additional research may be required.

Headquarters for these investigations are at Richmond, Virginia, and Oxford, North Carolina.

Project 5. Investigations of Insects Affecting Greenhouse and Ornamental Plants.

Objective: To develop or perfect measures satisfactory for the control of insects injurious to flowering and ornamental plants grown under glass or out-of-doors, vegetables grown under glass, flowering bulbs, and mushrooms.

The Problem: The general problem of insects affecting greenhouse and garden is very complicated because the individual problems are varied and subject to continually changing conditions. Sudden outbreaks of new pests may occur at almost any time. For example, the gladiolus thrips was first discovered in 1929 and within a few years spread to virtually all regions in the United States where gladiolus are grown. For a time the very existence of this popular garden flower was seriously threatened. Similarly, a recent outbreak of the rose midge on garden roses, which heretofore was known chiefly as a pest of greenhouse-grown roses, was responsible for numerous urgent requests made of the Department for information and assistance in coping with this problem. New insect problems are continually arising in the commercial florists' business due to the constantly changing fancies of the buying public. This necessitates the growing of new creations in floral production with their accompanying insect problems requiring prompt solution. Within the past two or three years there has been much interest shown in the commercial production of plants by the so-called water culture. This new method of production has

become known as "soil-less culture" and it may, in the near future, be generally adopted, necessitating a change in methods of insect control. The Department, in cooperation with commercial growers, is attempting to develop a new horticultural enterprise, namely, the growing in this country of Easter and other garden lilies to supply our own domestic needs. At present most of the bulbs are imported from Japan and other foreign countries. One of the problems already confronting this effort is the presence of serious virus diseases which are transmitted by certain insects. These examples illustrate the complex nature of the many insect problems involved in these investigations.

Each of the groups of plants cited above presents a distinct problem, inasmuch as all are highly specialized industries having requirements which must be met to the most minute detail. Due to the nature of the plants and the conditions under which they are grown, together with the unusually exacting requirements of the consumer, the infestation and damage by insects can be rapid and disastrous to the producer. The foliage and flowers of such plants are very susceptible to injury from the application of insecticides, thus making necessary the use of treatments that will cause no injury to the plants but will prove highly effective against the insect pests. Also of great importance is the avoidance of visible residues of insecticides on the ornamental plants and flowers.

Significance: The development of control of insects affecting greenhouse and ornamental plants is national in importance. Information on how to protect flowering plants is sought not only by the commercial grower who measures his production in square footage of area under glass but also by the backyard gardener with his small garden and the housewife who may have a lone geranium or fern infested with mealybugs. With the present garden club movement an unusual interest has been aroused in the growing appreciation of flowers for decorative purposes and personal enjoyment. With this increase in the growing of plants there has been a corresponding increase in the insect problems. As a result the demands upon the Department for information on how to protect the plants from the ravages of insects have reached enormous proportions.

The production of each of the crops included in this project constitutes an economically important industry as shown by the following official estimates of the average yearly values:

Crop	Value
Flowering Crops	$186,000,000
Greenhouse vegetables	52,000,000
Mushrooms (1933)	5,150,000

Although damage by insects and closely related pests attacking these crops varies greatly from season to season, and in different localities, it is estimated, on an average, that an aggregate loss equivalent to at least 10 percent of the value of these crops, amounting to the sum of approximately $25,000,000 is sustained from this

cause each year by the commercial growers, to which should be added a large total loss by the many flower lovers, and home gardeners, who grow these crops for their aesthetic value.

Plan and Progress of Work:

(a) Mites Affecting Greenhouse Plants: The plan under this work project is (1) to obtain information on the biology, habits, host relationships, and injury caused by the cyclamen mite, the broad mite, the bulb mites, and related species of mites on floral crops as a basis for developing control measures for these pests; and (2) to determine the effectiveness of acaracides, fumigants, immersion in hot water, and cultural practices in the control of these pests and the effects of such treatments on the host plants.

Headquarters for these investigations is at Beltsville, Maryland.

(b) Insects which May Carry the Mosaic Disease: The investigations under this work project have for their objectives the determining of (1) whether any strains or varieties of China aster are resistant to the virus disease known as aster yellows; (2) whether the insect vectors can be controlled by insecticides and thereby retard the spread of the disease; and (3) similar studies to determine the identity and methods of control of the insects that may carry the virus diseases affecting both commercial lilies forced in the greenhouse and the hardy garden types. Notable progress has already been made in the solution of the first two of the above-mentioned objectives, but much remains to be worked out.

Headquarters for these investigations is at Beltsville, Maryland.

(c) Iris Thrips Investigations: The studies that are being carried on under this work project include the completion of tests to determine the value of insecticidal dusts containing nicotine, derris and pyrethrum for the control of this important pest of Japanese and certain other types of iris.

Headquarters for these investigations are at Beltsville, Maryland and Brooklyn, New York.

(d) Greenhouse Red Spiders, Thrips, and Miscellaneous Pests: The objectives under this work project include (1) the obtaining of pertinent information on the biology of various pests including red spiders, thrips, whiteflies, aphids, mealybugs, and scale insects which infest various vegetables such as cucumber, tomato, and lettuce, and which also injure floral crops grown in the greenhouse and out of doors; and (2) determining the value of fumigants and sprays in the control of the pests mentioned above.

The results of four seasons experiments have shown conclusively that of the various spray combinations tested a spray consisting of derris powder, pyrethrum extract and sulfonated castor oil was rather

specific in its effectiveness against red spiders and thrips, especially on greenhouse-grown cucumber and tomato. Further testing is warranted with the spray combination, to be conducted on a larger scale in cooperation with commercial growers to ascertain its value when applied under practical growing conditions, especially on cucumber and tomato and later on some of the major floral crops such as roses, carnation, and chrysanthemum. It is also necessary to test the feasibility of substituting spreading and wetting agents for the sulfonated castor oil since some crops are slightly injured by the latter. Promising results were obtained in small scale tests against the red spider on carnation with glycerine as a substitute for the brown sugar in combination with tartar emetic. The glycerine leaves only a slight residue which is easily washed off and thus overcomes the objectionable dark residue left by sprays containing brown sugar. The effectiveness of this spray against other greenhouse and garden pests, especially the rose thrips, and the tolerance of some of the other important floral crops to it should be determined.

Work has recently been inaugurated to determine the feasibility of using methyl bromide as a general greenhouse fumigant, especially for the control of red spiders, mealybugs, and other important pests on many of the floral crops that are sold as potted plants, to meet the demands of the industry for information regarding its use. The results to date have been encouraging and a continuation of these studies is justified, especially since this fumigant is now used so successfully in the treatment of other horticultural commodities.

Preliminary tests with thiocyanate sprays and white oil emulsions either alone or when combined with suitable spreaders have indicated that these materials will kill large numbers of the various species of mealybugs on certain greenhouse crops and ornamental plants used in the home. Since considerable variation exists among the several species of mealybugs in their resistance to insecticidal sprays and fumigants, it is necessary to conduct further work on this problem so that simple and satisfactory control measures can be developed and adapted to the varying cultural conditions encountered. Since mealybugs are a limiting factor in the commercial production of many important flowering and ornamental plants and since the Department received daily numerous requests for information on how to combat them, further work on this problem is justified. This work should be expanded as other problems are completed.

Headquarters for these investigations is at Beltsville, Maryland.

(e) Gladiolus Thrips Investigations: The objectives under this work project are (1) to obtain such information on the biology of the gladiolus thrips as may be required in the development of control measures, and (2) to determine the relative toxicity of various insecticidal treatments to this insect where it infests corms or the growing plant.

Studies have revealed that injury by this insect is three-fold: (1) it feeds on the corms during storage, killing the dormant roots and buds; (2) it injures the foliage severely; and (3) it injures, when numerous, the buds and flowers so they are completely ruined. Extensive experiments have demonstrated that the thrips can be controlled on corms while in storage by applying naphthalene flakes, fumigating with calcium cyanide or a mixture of ethylene dichloride-carbon tetrachloride. During the past six years numerous insecticides were tested in an effort to find some material which would give control equal to that obtained with paris green and other arsenicals in combination with brown sugar, but which would not be injurious to the foliage.

The results of three seasons' tests demonstrate rather definitely that a spray consisting of tartar emetic plus brown sugar meets the desired requirements. Further work is needed, however, to determine the least quantities of each ingredient required and still remain effective, thereby reducing the cost of the spray. A calcium antimony tartrate gave results equal to those obtained with the tartar emetic. Should the availability of the antimony compounds become restricted as a result of the unsettled condition abroad, it would be necessary to experiment with other materials to find a suitable substitute. Large scale field tests should be undertaken also with commercial growers in important gladiolus producing regions, especially in Florida where climatic conditions vary to demonstrate the practical value of the above-mentioned sprays.

Headquarters for these investigations is at Beltsville, Maryland.

(f) General Bulb Insects Investigations: The objectives under this work project include (1) determining the important features of the biology of the various pests attacking flowering bulbs in the Pacific Northwest and in the important bulb growing areas in the East, including bulb flies, mites, thrips, and other insects or related forms which may be vectors of mosaic diseases; (2) determining the identity of the insects, mites or other forms which are responsible for the transmission of the virus or mosaic diseases of bulbs; and (3) determining the value of and improving existing control measures, including thermal treatments, fumigation, sprays, baits, cultural practices, or other methods in the control of the pests mentioned above and of the bulb nematode. (The work on the bulb nematode is being done in cooperation with the Bureau of Plant Industry.)

Very material progress has been made in the biological studies of the above-mentioned pests and the results have disclosed that normally the narcissus bulb fly completes its life cycle in one year although a few individuals require two years, and that the infestations range annually from 3 to 5 percent. Injury to narcissus by the lesser bulb flies was generally secondary. The lily bulb thrips was found to pass its entire life cycle between the scales of lily bulbs, an unusual environment for thrips. Damage by the bulb mite was found to be associated with some undetermined organism or physiological condition, although this point needs further study and confirmation.

Extensive experiments with hot water and vapor heat treatments have resulted in developing a fairly satisfactory method for use against the bulb flies, mites, thrips, and bulb nematode in narcissus and other bulbs so that it is now in general use among commercial growers. There are new angles, however, that are continually arising with the changing conditions of culture, climate, locality of production, and the introduction of new varieties so that these studies should be continued in order to find a solution for them. Similarly extensive experiments with fumigants have shown that the narcissus bulb fly, the lesser bulb flies, and the lily thrips can be controlled by fumigating infested stored bulbs with hydrocyanic acid gas. This point needs further study in order to render the treatment safer.

Environmental factors such as soil moisture and temperature appear to be important factors associated with injury to narcissus bulbs intended for greenhouse forcing when infested with the bulb scale mite. The influence that these factors have on reducing the mite population below the injury-causing level needs to be established. Preliminary tests using dry heat at moderate temperatures to control this mite in narcissus bulbs during the storage season have shown some promise. These tests should be carried to completion to determine the value of dry heat as an additional remedy.

The headquarters for this work are at Sumner, Washington, and Babylon, New York.

(g) Mushroom Insect Investigations: The following objectives are scheduled under this work project: (1) to obtain such information on the biology of various pests of mushrooms including flies, mites, springtails, and sowbugs as may be required to devise control measures for these pests; and (2) to improve existing control measures and develop new ones including the determining of the effectiveness of various fumigants, drenches, insecticide dust mixtures and sprays, light traps, heat, cold, and drying in the control of the above-mentioned pests.

The mushroom flies are particularly destructive since the larvae feed on the spawn, mycelium, cap and stems. The mites and springtails eat holes into the surface of the stem or cap and render the mushrooms unfit for sale. The mites are also especially destructive because they work through the mycelium from which the mushroom develops and destroys it entirely. The sowbugs eat larger holes in the caps and stems and thus ruin the market value.

A radically new method of composting manure is now being tested which in turn may serve as a valuable aid in reducing the subsequent insect population and perhaps eliminate the necessity for fumigating the houses at peak heat. Studies should be continued since fruitful results will in all probability flow from this work.

A number of materials, including free nicotine and alcoholic extract of pyrethrum, have been used as drenches upon the mushroom

beds or incorporated with the compost and have produced encouraging results but much remains to be done before definite conclusions can be drawn. Drying the mushroom beds indicated that a degree of dessication which permitted the spawn to survive was fatal to the larvae of the mushroom flies and adults of the mites. Similarly, exposure of the mushroom beds to freezing temperatures was found to aid somewhat in controlling the insects and mites. Further work with both of these procedures is desirable before definite recommendations can be made to the industry. A dust mixture containing 60 percent of ground flowers of pyrethrum and 40 percent of finely divided clay was found to be effective in controlling the adult flies within the houses. Since this mixture is very costly there is a definite need for developing a cheaper one. Preliminary surveys have been made on the seasonal fluctuation and sources of infestation of some of the more important mushroom pests. Since the information obtained from these will be useful in improving present control practices and devising new ones, further work is justified. Studies have been recently initiated to determine the value of burning smudges of pyrethrum and derris with promising indications.

The headquarters for this work is at Beltsville, Maryland.

(m) CEREAL AND FORAGE INSECTS

Appropriation Act, 1941	$379,500
Budget Estimate, 1942	379,500

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Cereal and forage insect investigations	$267,757	$269,045	$269,045
2. European corn borer investigations	78,828	78,968	78,968
3. Sugarcane and rice insect investigations	31,190	31,487	31,487
Unobligated balance	5,925	- - -	- - -
Total appropriation	383,700	379,500	379,500

WORK UNDER THIS APPROPRIATION

General. This appropriation provides for investigations on insects affecting cereal and forage crops including sugarcane and rice. Cereal and forage crops are the basis of agriculture over a large part of the United States. The insects attacking these crops annually cause immense losses, and in some areas the crops may be completely destroyed by these pests. The investigations conducted under this item are directed by the Division of Cereal and Forage Insect Investigations from headquarters at Washington,

D. C. The studies are conducted at field laboratories located in the important crop areas. The investigations are coordinated with those conducted on these crops by other agencies of the Department and also with those conducted by State agencies, certain problems being studied cooperatively.

Project 1. Cereal and Forage Insect Investigations:

Objective. To discover and improve methods for the prevention, control, and suppression of insects injuring corn, sorghums, small grains (except rice) and forage crops, including grasses, alfalfa and the clovers, during their growth in the field and during their storage and processing after harvest.

The Problem. These crops are attacked by many different insects. Some of these insects are injurious to both cereal and forage crops while others restrict their activities to single crops. Some of them are serious pests practically every year and others appear in injurious numbers only sporadically. Although these crops are the most essential and in the aggregate the most valuable ones grown their acre value is low. For this reason only comparatively small sums can be profitably spent by the individual farmer for the control of insect pests attacking them. Control measures must therefore be confined mostly to cultural measures, the use of resistant varieties, the application of cheap and easily applied insecticidal treatments, and, particularly in the case of foreign insect pests that have gained a foothold in this country, the introduction of their natural enemies. For the development of economical control measures a thorough knowledge of the life histories, and habits of the insects and their natural enemies is needed, as well as information on their distribution and the effects of crop rotations and other farm practices on their abundance.

Significance. The estimated average annual losses due to a few of the most important cereal and forage insects for which estimates are available are given below. While these losses are only a small percentage of the total values of the crops, they are to a considerable extent made up of severe injury to the crops attacked in restricted areas and individual fields, and thus become extremely important in these areas.

Insect	Crop	Estimated Average annual loss
Earworm	Corn	$79,200,000
Hessian fly	Wheat	13,018,000
Chinch bug	Corn, sorghum, and small grains	15,000,000
Grasshoppers	Cereal and forage	25,701,000
Grain and flour weevils and moths	Stored grains and cereal products	363,000,000
Alfalfa weevil	Alfalfa	891,000
Alfalfa caterpillar	"	750,000

Although much progress has been made in finding effective control measures for these pests, in many cases no effective and practical methods of control are known or those which are known are of very limited usefulness, and requests are being received constantly for advice and assistance in controlling the insects injuring the staple crops. The individual farmer is not responsible for their occurrence and does not have the knowledge or means to conduct the investigations necessary to the development of control measures. These pests are common problems transcending community and even State lines and since the solution of these problems is as much to the advantage of the general public as to any individual their investigation is properly the function of public agencies, including the Federal Government.

Plan and Progress of Work. Work now in progress which it is proposed to continue is summarized below. These projects are all of a continuing nature involving the accumulation of data for a considerable series of years under varying conditions, on the biology of the insects, the effect of cultural practices, the breeding of resistant varieties of crops, and the testing and improvement of insecticides. The investigations are necessarily of a long-time nature and while definite results are achieved each year progress is necessarily gradual.

The principal insects under investigation are discussed briefly in the following paragraphs:

Hessian Fly. The Hessian fly is the most important single insect pest of wheat. The amount of damage each year varies with conditions. The present and proposed work program includes the importation, redistribution, and evaluation of parasites; determination of safe dates for sowing winter wheat to avoid infestation; surveys to determine abundance of the fly and its parasites and the localities where safe seeding dates should be observed; and intensive studies in cooperation with Department and State agronomists to find and improve fly-resistant varieties of wheat. The work is conducted throughout the main winter-wheat growing regions from field stations located at Carlisle, Pa., Lafayette, Ind., Manhattan, Kans., and Sacramento, Calif.

Chinch Bug. The chinch bug is one of the most important pests of corn, sorghum, small grains, and other grass-like plants and occurs generally throughout the eastern half of the country. In occasional years it causes severe losses.

The present and proposed work program includes the testing, selection and breeding of resistant sorghums and corn varieties at Lawton, Okla., and Urbana, Ill. in cooperation with State and Federal agronomists; field tests of barley varieties at Lawton, Okla., Lafayette, Ind., Manhattan, Kans., and Urbana, Ill. to find resistant lines; and life-history, survey, ecological and cultural control, and insecticide studies at Lafayette, Ind.; and tests at Lawton, Okla. to determine the relation between plant nutrition and chinch bug resistance in sorghums.

Corn Earworm. The corn earworm is the most destructive generally distributed insect enemy of corn in the country and is an especially serious pest in the South. No satisfactory control is known for it in field corn.

The present and proposed work program includes the testing of corn varieties and strains for earworm resistance in cooperation with a number of Central, Eastern, and Southern States, conducted from Urbana, Ill., Lafayette, Ind., and Arlington, Va.; life history and hibernation studies to determine their relation to cultural measures of control and weather conditions; and the development of an insecticidal method of treating sweet corn ears to protect them from infestation.

A method of artificially infesting ears to insure decisive results in test plots has been improved during the past year with consequent advancement in the development of resistant varieties. Plot tests at Urbana, Ill., Lafayette, Ind., Weslaco, Texas, Arlington, Va., and by several cooperators at State stations showed several selected lines of corn to be materially and consistently resistant. A refined mineral oil fortified with a small percentage of pyrethrum extract or dichloroethyl ether for application to sweet corn ears as a preventive of infestation was further perfected by field tests in Florida and New Jersey, gave a high degree of control, and was used to some extent by commercial growers.

Miscellaneous Insects Attacking Small Grains and Grasses. There are many different species of insects which attack small grains and grasses. Among those which are now being or have been studied are the black wheat-stem sawfly, the European wheat sawfly, wheat jointworm, wheat strawworm, armyworms, etc. During the past several years the European wheat sawfly has occurred in outbreak numbers over considerable areas in Ohio and Pennsylvania and caused serious losses to wheat.

Current and proposed work consists of field surveys to determine the abundance of the two species of wheat sawflies and their parasites, including a parasite recently introduced from England; variety tests to determine sawfly resistance of different wheat varieties which are conducted from the Carlisle, Pa., station; and observations in wheat variety test plots which are conducted at the Carlisle, Pa., La Fayette, Ind., Manhattan, Kans., and Sacramento, Calif., field stations.

A solid stemmed variety, Golden Ball, was found resistant to the sawflies at Carlisle. Several wheat varieties were found to contain significantly low infestations of jointworm and strawworm at Sacramento, Calif. The Farmers' Bulletin on the jointworm and also the one on the armyworm were revised up to date during the year.

Insects Which Carry Diseases of Cereal and Forage Crops. A number of different kinds of insects carry diseases of cereal and forage crops. At present particular attention is being directed to those which are

thought to be carriers of Stewart's disease of corn. It has been definitely determined that at least two species of flea beetles transmit this disease and carry it over the winter. It is probable that these insects are the main carriers of the disease in the field. The most recent studies indicate that the disease is also carried over winter in plant hosts belonging to the grass family which serve to infect the beetles feeding on them early in the spring and on corn later.

<u>Alfalfa Aphid</u>. This insect causes severe losses wherever alfalfa is grown, particularly in Midwestern and Western States. Its abundance is somewhat periodic. Direct control by insecticides appears impracticable and cultural control measures have so far been of very limited application. In recent years certain strains of alfalfa have been discovered which are highly resistant to aphid attack. The current work therefore consists chiefly of the study of these and other strains in cooperation with Federal and State agronomists. Observations are also being continued on cultural measures of control and the possibility of utilizing certain fungous diseases of the aphid for controlling them in the field. The work is carried on from field stations at Forest Grove, Ore., Manhattan, Kans., and Sacramento, Calif.

<u>Insects Affecting Alfalfa and Clover Seed Production</u>. Several species of insects attack alfalfa and clover seed during their growth in the field and apparently are an important factor in the profitable production of these crops. Among them are included several species of sucking bugs and the alfalfa seed chalcid. No satisfactory methods of controlling them have yet been established but biological and ecological studies now in progress give promise of leading to effective control methods in the Western States where the main seed producing areas are located, by clean up of weeds serving as alternate hosts, clean cutting of alfalfa, and proper timing of the hay and seed crops. The possibilities of insecticidal control are also being investigated. This work is headquartered at Tempe, Ariz., and Delta, Utah.

<u>Insects Attacking Forage Crops</u>. The various forage crops are attacked by many different insects. One of these is the vetch bruchid, an introduced insect occurring in the Central Atlantic States where it has caused severe losses in seed production, in some counties as much as 50 percent of the entire crop. It was discovered in 1938 in the important vetch seed producing area in the vicinity of Portland, Ore. Other important insects which attack forage crops are the Western spotted cucumber beetle, an important pest of alfalfa and clover seedings in the Pacific Northwest; the European clover-seed weevil, recently found and now apparently increasing in the Willamette Valley of Oregon; the clover root borer and clover aphid which have recently been seriously injurious in Idaho; various leafhoppers which feed on alfalfa and often cause heavy losses in yield and reduce the vitality of the plants so that they are injured by winter killing.

During the past few years the biology, host plants, distribution of the vetch bruchid have been studied, comparative resistance of different varieties of vetch determined, and effective methods of fumigating infested seed been worked out. A European parasite has been introduced and apparently become established. Current work consists of experiments with insecticides for the control of the bruchid in the field and further surveys to determine its distribution and abundance. Studies on the insecticidal control of leafhoppers are also in progress. The work on these insects is carried on from field stations at Arlington, Va., Carlisle, Pa., and Forest Grove, Ore.

Grasshoppers. The importance of grasshoppers as pests of practically all kinds of cereal and forage crops has long been recognized and has been amply demonstrated by the extensive outbreaks of the past several years in some 24 States. There are many different species of grasshoppers that may occur in such abundance as to do excessive damage. When all the various kinds are abundant in the same season losses may be very great. The species differ in their habits, particularly as to plant associations favorable to egg-laying and their reactions to different habitats. The kinds which are usually present in cultivated fields are, in the main, quite different from the species which are so destructive to range lands. Comparatively little attention has been given to rangeland species except as they migrate into cultivated areas.

One of the prerequisites to the prevention of large outbreaks of grasshoppers such as have recently occurred is to locate centers of incipient infestation and apply control measures before the infestation builds up to outbreak proportions. To secure information of this kind surveys are carried on in cooperation with various State agencies. In this work the States contribute approximately one third the cost. Its value has been clearly shown in the last few years. The information secured serves as the basis for the organization of cooperative control work the following season. Without it the intelligent direction of informational work regarding the outbreaks, or distribution of bait materials made available from various sources, would be impossible. The continuation of this survey work will not only supply advance information on prospective outbreaks but will also provide data on occurrence and distribution in relation to environmental factors, information essential in the development of control measures, improvements in survey methods and the formulation of policy on ways of combating these important pests.

It is proposed to continue the work now in progress which consists of experiments for the improvement and reduction in cost of poison baits and methods of applying them, studies on cultural methods of control, observations on the natural enemies of grasshoppers, systematic studies of their habits and the ecological factors influencing their abundance with a view to adapting control measures to the prevention of outbreaks, and thorough surveys basic to both research and control operations. These activities are conducted from the following stations: Bozeman, Mont., Forest Grove, Ore., Tempe, Ariz., and Wichita, Kansas.

Notable results during the past year are the accumulation of data on the suitability of substitutes for bran and sawdust in baits, the feasibility of using the less poisonous sodium fluosilicate instead of the more dangerous arsenicals, adaptation of baits for more effective distribution from airplanes, and modifications in survey methods to reduce their cost and increase their dependability.

Mormon cricket. During the past several years, the Mormon cricket and its near relative, the Coulee cricket, have occurred in unusual abundance in certain sections of the Rocky Mountain and Great Plains States, with attendant loss of range forage and cultivated crops where in proximity to range. In combating these outbreaks the need for more effective and readily applicable methods for control has been emphasized, as well as information as to the causes of outbreaks and the possibility of applying measures to prevent their occurrence. The work now under way includes studies of insecticidal dusts and baits, and observations on biology, survey methods, status and distribution, with headquarters at Bozeman, Montana.

Recent accomplishments are the development of a cheap and effective bait, information on the relation of particle sizes of insecticidal dusts and carriers to their efficiency, the relation of moisture to viability of cricket eggs, the food plants preferred by and the amount of damage to the range caused by the crickets, and data on methods of sampling for use in survey work.

White Grubs. These are the immature stages of June beetles and are important pests of sod lands, pastures and cereal crops. Serious damage has occurred over considerable areas in the North Central States region in the past few years and also in the Southern Great Plains. The adult beetles of many species also cause injury by eating tree foliage. There are a large number of native species and the life history of various forms differs. Some species complete their life cycle in one year, while others may extend it for two, three, or four years. Methods now available for the control of white grubs are unsatisfactory. In an effort to develop more effective control measures studies are being conducted on distribution, habits, food preferences, effects of different crop rotations on abundance, and insecticidal control, in cooperation with the State experiment stations at Lafayette, Ind., and Madison, Wisconsin.

Diseases of Cereal and Forage Insects. Many of the common pests of cereal and forage crops are attacked by fungous diseases. Comparatively little is known regarding these diseases or conditions under which they may become abundant. Investigations are conducted at the Forest Grove, Ore. and Arlington, Va. laboratories to determine the possibility of using these diseases as an aid in control. One notable result to date is the separation of two forms of a fungous disease attacking wireworms, one of which appears to be much more effective than the other.

Insects Attacking Stored Grain Products. It is conservatively estimated that 5 percent of the cereal grains and products are destroyed or damaged by various insect pests while the grain or products are held in storage or during the process of milling and shipping. These losses approximate nearly $400,000,000 annually and are caused by comparatively few species which occur throughout the world.

Investigations on insects attacking grain during storage, milling and shipping are headquartered at Manhattan, Kans. The studies are carried on largely in commercial mills, elevators and storage warehouses or bins throughout the main grain producing regions, and are directed to securing accurate information regarding more effective control methods. One of the most widely used methods is fumigation and special attention is given to determination of the most effective gases, dosages and methods of application. These studies involve the determination of the conditions of temperature, wind, and other environmental factors and their influence on the effectiveness of various fumigants and dosages. Studies are also conducted on the effect of the fumigants on the germination of the grain, and the relation of the temperature and moisture of the grain to the survival of the insects feeding on it.

Outstanding results during the past year have been observations on the high effectiveness of methyl bromide as a grain and mill fumigant, determination of temperatures lethal to insects as a basis for using heat treatment in control operations, the dosages of fumigants usable on grains of different moisture contents without injury to germination, the determination that wheat became infested after storage rather than in the field before harvest, the observation that inert dusts, such as often recommended for control of insects in stored grains, are of very little value, promising methods of treating the incoming grain stream in mills to prevent entry of insects with the grain, the principal source of mill infestations, and the determination of dosages of fumigants necessary to fumigate grains in farm bins effectively.

Legume Weevil. A foreign weevil was discovered in 1939 to be well established in the vicinity of Yuma, Arizona where it was feeding on several legumes, including sour clover and alfalfa. An intensive survey early in 1940 also revealed its presence at Tempe, Arizona. In view of its possible importance as a pest of legumes, it has been closely studied since its discovery to determine its life history, habits, food plants and possible methods for its control or eradication. The continuation of similar studies is planned.

Many of the insect pests of cereal and forage crops were accidentally introduced into the United States. Their natural enemies in many cases were left behind. Until the outbreak of the European war in 1939 efforts were being made to import these, with special attention to the parasites of the hessian fly, European wheat sawfly, and the vetch bruchid. These efforts have necessarily been redirected to a search in South America for parasites of the white-fringed beetle, European corn borer, and other pests that occur on both American continents.

The White-fringed beetle. This is a South American insect which during the past three years has been found in limited sections of four of the Gulf States. It is a very destructive pest of cotton, corn, legumes and vegetable crops.

Intensive study of its biology and habits is essential to the eradication, suppression and control operations now being conducted with funds provided under the general authorization for the control of incipient and emergency outbreaks of insect pests, and should be continued. In cooperation with the States concerned the studies are being conducted at Florala, Ala., Gulfport, Miss., and New Orleans, La., and in addition to those primarily concerned with its biology include systematic and thorough studies of host plants and plant associations, and control by means of cultural measures, insecticides, baits, soil fumigants, and mechanical barriers.

Some of the salient points determined are that the adults appear during the summer, that both they and the larvae can subsist on a great variety of both wild and cultivated plants, that the adults are all females, crawl actively but are unable to fly, are very prolific egg layers, and are readily susceptible to the common insecticides applied to their food plants, that the larvae live in the soil and eat the roots and tubers of plants, that there is approximately one generation a year, and that beetle populations can be much reduced by the application of insecticides to kill the adults, weed killers to starve them, and summer fallow of infested land to starve both larvae and adults.

Project 2. European Corn Borer Investigations:

Objectives. To originate and develop effective and economical methods of controlling the pest, to breed and colonize the insect parasites which attack it, and to conduct surveys in order to determine the status of the borer and its parasites.

The Problem. The European corn borer is a serious pest of both field and sweet corn in the northeastern portion of the country. It also breeds in some vegetables and weeds. The insect spends most of the year as a small, boring caterpillar inside the growing or dead stalks of its host plants. Hence there is constant liability of its transportation, through commerce, to uninfested territory. This habit also renders the insect amenable to control through cultural methods applied on a broad community basis. Insecticidal methods of control in sweet corn of high market value, which can be applied by the individual grower, have been found but such control methods for application to canning corn or field corn are still to be discovered.

Significance. Losses caused by the corn borer to the crop have been serious in the States affected. Estimated annual losses for the past three years were as follows:

1939 - $4,000,000	)	
1938 - 2,250,000	)	Average for 3 years - $2,833,333.
1937 - 2,250,000	)	

Apparently the insect is increasing in the seriousness of its attacks.

Plan and Progress of Work. The research operations now in progress and which are to be continued are described below. These projects are all of a continuing character. The local phases of some of them may be completed from time to time, but as the infestation spreads to new regions, fresh studies may be required in order to adapt control measures to the new conditions thus created.

The greatest total damage by the insect to corn harvested for grain occurred in Ohio, Michigan, and Indiana, or $853,655; $491,627; and $200,687, respectively. The highest loss of sweet corn in any one State occurred in Massachusetts and was $614,778.

The data accumulated through these activities are communicated annually to all State authorities and others interested.

The corn-borer research is conducted under the following projects:

(a) Investigations to Determine Varieties of Corn Tolerant to Attack: Although a practical degree of control is achieved through special farm operations, the ideal control would be one that automatically prevented attack or which reduced it to a negligible minimum. Production of corn varieties which are resistant, or markedly tolerant to corn borer attack is the objective of this project. In 5 years (1935-1939) of its operation 690 corns were tested. Among strains of sweet corn carried for 3 years selections of Bantam gave most favorable indications. Acceptable evidence of inherent resistance was obtained with 7 of these strains. With the field corns material resistance was exhibited by 10 lines, some of which have remained consistently resistant for several years. The production of commercial varieties of these strains is necessarily a slow process which cannot be hurried if reliable results are to be expected.

(b) Insecticidal Control: Although control of the corn borer, through community adoption of certain cultural methods, has been obtained, there is need of a method by which the individual grower may protect his crop independently. The application of insecticides, if successful, would afford such independent control. Although there is no immediate prospect that insecticidal control would prove practical for field corn, this method already has been demonstrated as effective and practical for early market sweet corn of high market value and for home garden use. The present work is aimed at the possible development of insecticidal control of the borer in sweet corn produced for canning purposes. Corn borer damage to this crop at present is estimated to be at the rate of 4-1/2 percent per borer per plant per acre. The economic loss to this crop in badly infested areas is heavy, but this is not the only consideration which urges action on this problem as the possible inclusion of even minute fragments of the borer in canned corn immediately destroys the marketability of the product.

Several spray materials, including Cryolite, have been found to give practical control. The Cryolite is the simplest and cheapest of the materials yet discovered, but rather serious burning of the plants results from its application and efficient adhesive to prevent rain from removing it are still wanting. Effort is being made at present to overcome these defects with the prospect that this eventually will be accomplished.

(c) Determination of the Value of Natural Enemies in the Control of the Borer: An ideal method of control for the corn borer would be, if successful, the utilization of its natural enemies to subdue it. Efforts in this direction have resulted encouragingly in some localities where insect parasites introduced by this Bureau from Europe and the Orient have become established and have multiplied significantly. For instance in one locality, along the shore of Lake Erie in western Ohio, one of these parasites in 1938 was found to have destroyed as high as 80 percent of the borers. In Hartford County, Connecticut, parasitism by several introduced species was over 37 percent and in the central part of the State parasitization by a single species ran as high as 72 percent of the borers. Although the World War has terminated introduction of parasites from abroad, the redistribution through artificial means of parasites already established in this country is proceeding steadily. Thus, newly infested areas may receive this aid as soon as the populations of the borer are great enough to warrant an attempt at introducing its parasites from older parasitized regions.

(d) Seasonal Development, Biology, Ecology, and Field Status of the Borer: In order to keep this pest under surveillance and to determine its relative economic status annually, a survey is made of certain typical corn growing areas in several infested States. Thus it was shown that in 1939 the insect increased its damage to the corn crop by more than 75 percent. The total damage inflicted was $4,000,000 to the crop valued at nearly $106,000,000 in 285 counties in the Northeastern States. Of this crop 5,274,190 acres were harvested for grain and 181,454 acres for sweet corn. This loss was distributed as follows: Ohio, Michigan, Indiana, Wisconsin, northwestern Pennsylvania, and western New York, $1,936,620; New England, New Jersey, Delaware, Maryland, Virginia, eastern New York, and northeastern Pennsylvania, $2,040,506.

Project 3. Sugarcane and Rice Insects.

Objective. To develop or improve methods of control for the insect pests attacking sugarcane directly as well as those that act as vectors or carriers of disease attacking this crop. To originate methods of control for insects attacking rice both under growing and storage conditions.

The Problem. Insects annually take a heavy toll of the sugarcane crop both by direct injury to it and as an agency in disseminating sugarcane mosaic and other diseases. Control measures in the past for the

sugarcane borer have been only palliative and have consisted in cultural methods which sought to avoid maximum infestation and damage. Recently, however, insecticidal measures have been revealed which promise a substantial degree of practical control. In addition to this, every effort is being made to introduce from tropical America insect enemies of the borer and to establish these both in Florida and Louisiana. The insect known as the corn leaf aphis was discovered some years ago to be involved in the transmission of the mosaic disease of sugarcane. Recent work under this project, however, has revealed that at least two additional species of insects are implicated in spreading this very injurious disease which at one time almost wiped out the sugar industry in Louisiana. Present investigations seek to elucidate the definite relationship of these insects to the disease.

Control is also sought for insects of somewhat less importance, such as the sugarcane beetle, the West Indian cane fulgorid and wireworms which, collectively, inflict serious damage to the sugarcane crop. Of the insect enemies of growing rice in Louisiana the stinkbug is the most serious offender. Its attacks are one of the causes of a defect known as "pecky rice" that seriously reduces the market grade of the crop. Other injurious species are the rice stalk borers and the sugarcane beetle which attack the stalks. The rice crop in storage is widely and seriously attacked by a variety of stored grain insects, the most injurious of which are the rice weevil and the Angoumois grain moth.

Significance. Of the insects attacking sugarcane, the sugarcane borer alone is estimated to have caused in 1939 a loss to the crop of $4,231,000, or more than 1/4 of the value to the grower of the entire crop estimated by the Bureau of Agricultural Economics as $15,327,000. This loss is considerably higher than for several years past and the average loss for ten years is estimated at $2,791,000 annually. Although palliative control measures, such as treatment of seed cane with hot water, and the burning of cane trash in the field, have resulted from past studies of this pest, only recently has a promising insecticidal control measure been discovered. The present efforts are being directed mainly along these lines.

The insects attacking rice in the field are estimated to damage the crop seriously. The loss from pecky rice alone is estimated to reach as high as $400,000 annually. The insect damage to rice in storage is much greater and is estimated at $2,150,850 annually.

Plan and Progress of Work. Work at present under way which it is proposed to continue is summarized below. These projects are continuing in character and require the accumulation of data over a considerable series of years under varying conditions on the biology of the insect, their reactions to cultural insecticidal and other methods of control, and the comparative incidence of abundance and losses to crops over long periods of years.

The investigations conducted under this project include the following:

(a) Sugarcane Borer: This insect, a boring caterpillar, causes immense damage to the crop as previously described. An average of 19.75 percent of the joints of the cane were bored by it in 1939. Experiments in dusting the cane with an insecticide, viz: synthetic cryolite, during the past two seasons have resulted in reducing its attacks to less than one-half those observed in untreated areas. This treatment was estimated to have saved the crop to the value of more than $11 per acre and it is proposed to continue these experiments.

(b) Insects which may Carry Sugarcane Disease: One of the principal limiting factors in sugar production in Louisiana is the mosaic disease of sugarcane which is known to be transmitted importantly by insects. It is estimated to cause an average annual loss of $500,000 to the crop and this loss appears at present to be increasing. The corn leaf aphis has for some years been known to transmit this disease, but recent work under this project has revealed that both the rusty plum aphid and the green bug or spring grain aphis may likewise carry this disease from corn and grasses to sugarcane. A disease known as chlorotic streak has recently made its appearance in Louisiana and the relationship of insects to the spread of this disease is being investigated.

(c) Miscellaneous Insects Attacking Sugarcane: A group of minor pests of sugarcane collectively cause substantial losses annually to the sugar crop in Louisiana. Of these, the sugarcane beetle is the most injurious. It bores into the bases of the young canes thus killing the heart or growing point. Populations of as many as 100,000 beetles per acre are sometimes present in the fields. The adult beetles cause the damage and control by the use of trap-lights, resulting from work under this project, is giving excellent results on many plantations. A cultural method also derived from it is the planting of cane varieties that have a habit of stooling abundantly, thus producing supernumerary plants. Other insects in this group are the West Indian cane fulgorid, only recently introduced in Florida, and the sugarcane root stock weevil.

(d) Insects Attacking Rice in the Field: Although the insect enemies of growing rice in the Gulf States are not of many kinds, they are estimated to cause a loss of about $1,000,000 annually. The most injurious of these is the rice stinkbug which sucks the substance from the developing kernels thus causing empty hulls and also causing a defect in the marketed grain known to the trade as "pecky rice". The annual loss from this insect is considered to be at least $400,000. Clean culture on rice land secures partial control of this pest, but no fully effective method has yet been discovered. The sugarcane borer and the rice stalk borer also attack growing rice in Louisiana and inflict

damage estimated at $445,000 annually. Experimental dusting with cryolite is in progress and gives some promise of good results. It has also been discovered recently that several of the more important insects attacking stored rice begin their depredations in the field and thus are carried with the grain into storage when it is harvested. The sugarcane beetle also attacks the stalks of growing rice but a method of control resulting from this project, viz: flooding the fields at a critical period has greatly reduced the attacks of this pest.

(e) Insects Attacking Rice in Storage: The rice crop in storage is singularly subject to attack by insect pests. The crop in 1939 amounted to 14,500,000 barrels and the carry over in 1938 was 290,000 barrels of rough rice, 736,700 pockets of clean rice and 113,632 pockets of brokers' rice. This crop is stored principally in loosely constructed buildings that offer little obstacle to the ingress of flying insect pests, and are generally not of tight enough construction to permit of efficient fumigation. As infestation of rough rice begins in the field the crop is always infested in some degree when it enters storage. Investigation has shown that grain containing 12 percent or more of moisture is most favorable for the development of insect infestation. Rice, as it enters storage, invariably contains 14 percent or more of moisture, thus offering most favorable conditions for insect development of which the insects take full advantage. An experiment conducted under this project in 1939 showed that rice harvested in 1938 and placed in storage had lost, by May 2, 1939, 4.4 percent of its weight from insect feeding. On November 21 following, or 12 months after storage began, this loss had increased to 21 percent of its weight.

The principal insects responsible for such heavy losses in rough rice are the Angoumois grain moth, the rice weevil, the Cadelle, the lesser grain borer, and the rust-red flour beetle. All of these insects are well known, widely distributed pests of stored grains in general. Clean rice is injured by a further group of pests, such as the Indian meal moth, the saw-tooth grain beetle, and others. Fumigation with gases lethal to these insects is receiving exhaustive investigation under this project and is efficient when performed under proper conditions. Owing to the loose construction of most rice mills and warehouses fumigation is conducted in especially constructed chambers or vaults under either atmospheric or vacuum conditions.

(n) EUROPEAN CORN BORER CONTROL

Appropriation Act, 1941...............$27,939
Budget Estimate, 1942................ 27,939

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Inspection and certification of products regulated by quarantines on the European corn borer..................	$26,260	$27,939	$27,939
Unobligated balance............	6,679	- -	- -
Total appropriation........	32,939	27,939	27,939

WORK UNDER THIS APPROPRIATION

Objective: To provide an inspection and certification service for plant material likely to harbor European corn borers and destined to States which have promulgated plant quarantines or regulatory orders prohibiting the admission to their environs of such host material unless it has been inspected and certified by the United States Department of Agriculture.

The Problem and Its Significance: (1) On June 15, 1932 the Federal European corn borer quarantine was revoked, and the protection of uninfested States from spread of this pest by means of host material from infested States became a problem for each individual State. This resulted in a wide variety of State plant quarantines, a number of which limited the entry of products likely to carry corn borer infestation to those certified by the United States Department of Agriculture as being free from infestation. Nine States, Arizona, California, Colorado, Georgia, Louisiana, Nevada, Oregon, Texas and Utah, still maintain plant quarantines requiring Federal inspection of host material entering from infested States. The corn borer is known to infest in their entirety or partially the six New England States, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, Kentucky, West Virginia, Ohio, Indiana, Michigan, Illinois and Wisconsin. Host products designated in the State quarantines consist of corn, broomcorn, sorghum, sudan grass, chrysanthemums, asters zinnias, cosmos, hollyhocks, dahlias, gladiolus, beets with tops, celery, beans, rhubarb and oat and rye straw. The problem therefore is one of furnishing a moderate amount of inspection over a considerable expanse of territory. Fortunately, with the exception of a few States, the area infested with the corn borer is conterminous with the areas quarantined on account of the Japanese beetle and the gypsy moth, and some of the products requiring corn borer certification are also

regulated under one or the other of these two Federal quarantines. This makes it possible to make dual certifications in many instances. It is this condition that permits the establishment of the corn borer inspection service over the entire area at a minimum of expense. It is only in the States of Indiana and Michigan that inspectors engaged exclusively in corn borer inspection and certification must be maintained independently of the other regulatory activities.

(2) The inspection demands have been rather stabilized over the past three fiscal years, and it is possible to supply adequate inspection with the present inspection force. On a comparative basis, the number of inspections made and the value of products certified has been as follows:

Fiscal year	1938	21,460	shipments	inspected	valued	at	$199,000	
	1939	50,190	"	"	"	"	157,000	
	1940	37,800	"	"	"	"	206,000	
	1941	40,000	"	"	"	"	210,000	(estimated)
	1942	50,000	"	"	"	"	225,000	(estimated)

Plan of Work: Inspectors stationed at field headquarters scattered throughout the area infested by the corn borer meet the demands of shippers for Federal inspection and certification. The inspectors visit the nurseries, greenhouses, farms or produce houses from which the products are to be shipped and make actual inspections on the shippers' premises, without charge. Certificates are furnished for affixing to containers of borer-free material.

(o) BARBERRY ERADICATION

Appropriation Act, 1941	$162,500
Budget Estimate, 1942	182,500
Increase	20,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Increase
1. Barberry Eradication:				
(a) Eradication of the barberry in the 13 States where work was begun in 1918	$148,522	$137,050	$157,050	+ $20,000(1)
(b) Eradication of the barberry in other States	20,800	20,800	20,800	- - -
(c) Inspection of nurseries which ship barberries interstate	4,650	4,650	4,650	- - -
Unobligated balance	1,028	- - -	- - -	- - -
Total appropriation	175,000	162,500	182,500	+ 20,000

INCREASE

(1) An increase of $20,000 is requested to provide technically trained supervisors and equipment necessary to resume eradication of rust-spreading barberry bushes in a portion of the area (North Dakota, South Dakota, Montana, and Wyoming) in which work was suspended during the fiscal year 1941 because of a lack of funds with which to employ trained and experienced supervisors and to provide transportation for locally employed laborers.

The Problem: Following two reductions in the regular appropriations for barberry eradication (1940 and 1941), it has been necessary to discontinue control operations in North Dakota, South Dakota, Montana, and Wyoming. The increase requested herein will provide funds with which to resume in a portion of this area field work that is urgently needed, thus preventing the regrowth and further distribution of bushes in some of the known areas of infestation where initial work has been completed. By supplementing funds available from regular Departmental and State sources with transfers from the Work Projects Administration, a vigorous program, since 1935, has reduced the barberry population in these States to a point where future work is largely of a clean-up nature. This type of program requires a relatively higher ratio of trained assistants to inexperienced laborers than is necessary in States where barberry bushes are abundant and an extensive eradication problem remains.

Significance: North Dakota, South Dakota, Montana, and Wyoming produce 264,924,000 bushels of small grains annually; 157,793,000 bushels of this is hard red spring (bread) wheat. These four States and Minnesota produce approximately 73 percent of the spring wheat grown in the United States.

Black stem rust is the most destructive of all diseases that attack wheat. During the 5-year period, 1916-1920, losses caused by this disease averaged 57,700,000 bushels annually and the greatest amount of damage occurred in the above-named States. Stem rust is caused by a fungus that lives on the leaves of certain species of barberry bushes in the spring and on grains and grasses during the remainder of the year. It spreads by means of dust-like spores that may be carried by the wind for many miles from the bushes on which they are produced.

The stage of rust which occurs on grain plants does not survive the winter in the northern part of the United States. There are, however, two sources of rust for this area, (1) spores which develop on local barberry bushes and spread to grains and grasses as the crops develop, and (2) spores which are blown up from the south (Texas and possibly Mexico) where the disease often survives the winter in the summer or spreading stage. Rust spores that develop on local barberry bushes may be found early in the spring while rust spreading from the south does not appear in the northern States until later in the season, often after crops have passed the stage of development when extensive damage is likely to occur.

In view of the great distances to which most spores may spread from a single source of inoculum, it is essential that all barberry bushes in the above-named States be destroyed. Progress during the past five years has indicated that this is possible and practicable. In these States the initial survey has been completed but known infested areas must be reinspected at frequent intervals to prevent seedling bushes from developing. Rust surveys must be made to determine where local sources of inoculum remain, and a systematic resurvey program is needed to locate and eradicate bushes that so far may have escaped detection.

In epidemic years stem rust destroys millions of bushels of grain and the cost of completing barberry eradication is only a minute fraction of the damage that is likely to occur in a single year if control operations are suspended and bushes are again permitted to become widely distributed in this area.

Plan of Work: In the Dakotas, Montana, and Wyoming, inexperienced laborers can be used effectively only when employed in small units and under the immediate direction of a trained supervisor. Plans for carrying out a clean-up program require a Leader in charge in each State and three to five trained assistants who will make systematic resurveys of known infested areas. They will conduct rust surveys to determine where and to what extent rust is causing damage, and whether or not there are local sources of inoculum which are responsible. Labor will be employed only when extensive timbered areas are encountered which require an intensive survey to eradicate bushes that have grown from seed distributed by birds and other agencies before the initial survey was made. In Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, Pennsylvania, Virginia, West Virginia, and Wisconsin a vigorous systematic intensive survey should be continued until initial protection has been extended to all counties. The program in these States is more than half completed, but there is an urgent need for additional trained assistants to carry out control operations in the open type of territory where the ratio of trained men to relief labor must be higher than is permitted under WPA regulations, if effective work is to be done.

WORK UNDER THIS APPROPRIATION

Objective: To eliminate barberry bushes from the northern grain-growing sections of the United States extending from Pennsylvania and Virginia to Montana, in order to reduce or prevent losses from black stem rust of grains.

The Problem: Black stem rust causes more damage to small-grain crops in the United States than any other disease. During the 5-year period, 1916-20, it took an annual toll of more than 57,700,000 bushels of wheat. Twice since 1915 losses for a single year have exceeded 100 million bushels. To date the Federal Government has expended a total of only $13,260,000 on barberry eradication in 17 states and the program is more than half completed.

Rust is caused by a fungus that lives on the leaves of certain species of barberry bushes in the spring and on grains and grasses during the remainder of the year. It spreads by means of tiny dust-like spores that may be carried by the wind for miles from the bushes on which they are produced.

To protect grain crops from stem rust has been foremost in the minds of farmers in central and western States for nearly 40 years. It was not until 1918, however, that a regional control program involving 13 North-Central States was undertaken. In 1933 the protected area was extended to include Missouri, and, in 1935, after repeated attempts to control stem rust locally had proved unsuccessful, similar cooperative programs were undertaken in the grain-growing areas of Virginia, West Virginia, and Pennsylvania. In combating the stem rust disease two main objectives have been followed: (1) The eradication of barberry bushes which serve as local sources of inoculum; and (2) the development of varieties of grain that are resistant to the disease.

Significance: There are several different ways in which to measure benefits that farmers, processors, and the consuming public have derived from the barberry eradication program to date. (1) Losses from stem rust of wheat that averaged more than 57,700,000 bushels annually during the period 1916-20 have been reduced to an average of 29,598,000 bushels annually for the period 1930-39, despite two years during that decade when comparatively heavy rust losses were experienced in the upper Mississippi River Valley States as a result of the south-to-north movement of rust for which local barberry bushes were not directly responsible. (2) The total cost of barberry eradication to the Federal Government during the past 20 years represents less than one-half of the resulting annual savings to grain growers. As the barberry population is further reduced these savings will be increased and protection for future crops extended indefinitely. (3) The control of stem rust has helped to eliminate wide fluctuations in yields and quality of grains produced in the United States, thus contributing in an important way to stability of production and price. (4) Perhaps the most important benefit of all is the fact that if the organized control program, undertaken in 1918, had been delayed a few years longer losses from stem rust would have continued to increase as barberry bushes became more prevalent, and the cost of a successful control program would have been infinitely greater.

Plan and Progress of Work: The earlier years of barberry eradication program were taken up largely with educational work, field demonstrations and organization of control campaigns in limited areas where the most severe losses from stem rust were occurring.

With labor available during the past five years from emergency relief sources, an intensive survey has been made of approximately 70 percent of the area where a detailed inspection of all uncultivated lands is necessary in order to locate and eradicate bushes that were growing along fence rows, rivers and streams, in pastures, and on timbered lands. Infested areas in the territory covered have been carefully mapped, individual properties recorded, and other data compiled which clearly

indicate where future reinspections will be necessary, thus eliminating from further attention much of the territory covered during the first complete survey.

A vigorous program during the next few years is particularly important in order to prevent seedling bushes from developing in areas where the initial work has been completed, and to complete the survey of remaining counties before bushes are allowed to spread further. The total cost of completing the barberry eradication program will amount to less than half the value of the wheat destroyed by stem rust in a single year.

Since the emergency program started, this intensive survey has covered an average of about 50,000 square miles per year, the areas in the fiscal year 1940 have a total of 46,404 square miles. Within this area 31,331,042 barberry bushes have been destroyed, largely through the application of salt or salt brine on the roots. A total of 1,636 tons of salt have been used, on 2,728 different properties.

A Federal quarantine prohibiting and regulating the movement of barberry plants is enforced, and a small part of this appropriation is used for the inspection of nurseries which ship barberry plants interstate. Certain varieties of barberry are immune to the disease and under appropriate inspection and certification can move without risk. The movement of rust-susceptible varieties is prohibited.

SUPPLEMENTAL FUNDS

Direct Allotments

Project	Obligated, 1940	Estimated obligation, 1941
Emergency Relief Appropriation Acts:		
Barberry eradication..................	$880,311	$441,509

(p) COTTON INSECTS

Appropriation Act, 1941.............	$144,544
Budget Estimate, 1942	144,544

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Cotton Insect Investigations:			
(a) Insecticides for boll weevil control, investigations of	$17,782	$18,000	$18,000
(b) Seasonal development, biology, ecology, and status of the boll weevil, investigations of	10,800	11,000	11,000
(c) Boll weevil control on Sea Island cotton, investigations of	11,400	11,500	11,500
(d) Varietal resistance to the boll weevil, investigations of	5,000	5,000	5,000
(e) Natural Enemies of the pink bollworm, investigations of	5,800	5,200	5,200
(f) Insecticides for pink bollworm control, investigations of	5,000	5,000	5,000
(g) Cultural practices and varietal resistance for control of the pink bollworm, investigations of	7,900	8,000	8,000
(h) Seasonal development, biology, ecology, and status of the pink bollworm, investigations of ...	9,500	9,500	9,500
(i) The cotton flea hopper and related insects, investigations of	18,000	18,000	18,000
(j) Stainers and stink bugs injurious to cotton, investigations of	13,000	13,000	13,000
(k) Bollworm, investigations of	8,000	8,000	8,000
(l) Leaf aphids injurious to cotton, investigations of	5,500	5,500	5,500
(m) Root aphids injurious to cotton, investigations of	5,000	5,000	5,000
(n) Thrips injurious to cotton, investigations of ..	4,000	4,000	4,000
(o) Seasonal occurrence, distribution, damage, and biology of various cotton insects, investigations of	6,544	6,544	6,544
(p) Dissemination of information to the public regarding cotton insects and their control.......	10,300	10,300	10,300
(q) Importation of natural enemies of cotton insects	300	1,000	1,000
Unobligated balance	718	---	---
Total appropriation	144,544	144,544	144,544

WORK UNDER THIS APPROPRIATION

General. This appropriation provides for investigations on insects which attack cotton plants and crude cotton products, and for the development or improvement of methods for their control. Cotton is one of the important agricultural crops and one on which the agriculture of the South depends. The products produced from cotton form an important part of industrial occupations in many sections of the United States. Cotton is attacked by many different kinds of insects. The importance of the various species varies with the season and the locality. One of the outstanding pests is the boll weevil. Investigations on this item are carried on in cooperation with the states whenever practicable, but only comparatively few states are engaged in investigations on insects attacking cotton. Those phases of the studies having relation to other activities of the Department are carried on in cooperation with the interested Bureaus. The work is directed by the Division of Cotton Insects with headquarters in Washington, D. C., and field laboratories are maintained in localities favorable for the investigations.

The various activities are described in the following paragraphs:

Project 1. Investigations of Cotton Insects:

Objective: To study the life history, habits, and host plants of the many species of insects attacking cotton, to discover and develop new methods of control, and to improve and make more practical the measures now in use for reducing the insect damage in order to increase the yields and lower the cost of production.

The Problem and Its Significance: Cotton is grown in 19 states and is the most important crop in 12 of the southern and western states. More people are engaged in the production, handling, and processing of cotton than any other crop grown in the United States. It is one of the principal export commodities and a most important item in maintaining a favorable trade balance with other countries. The losses caused by insect damage is the principal handicap to the production of cotton. The Bureau of Agricultural Economics estimates the reduction from full yield caused by insects at about 15 percent of the crop or some two million bales annually, valued at $150,000,000 at present prices.

Many of the insects are native although some of the most important are foreign species. The most notorious, the boll weevil, reached southern Texas from Mexico about 1892 and spread to new areas until by 1922 it had covered all of the cotton belt except the semi-arid areas of the West where climatic conditions are unfavorable. It was feared that the boll weevil would ruin the cotton industry but improvements in cultural practices and varieties of cotton reduced the losses, and after years of effort entomologists and chemists of the Department developed a new insecticide, calcium arsenate, especially for boll weevil control. Calcium arsenate is effective and 15 to 30 million pounds are used each year for the control of

the boll weevil and other cotton insects, but it has certain disadvantages. New facts regarding calcium arsenate and other insecticides that are being tested as substitutes are discovered from year to year and many improvements will probably be made as investigations continue. Despite the progress that has been made on its control the boll weevil continues to cause an estimated damage of about 12 percent of the crop, and control measures should be much more generally used.

The pink bollworm is a native of India which has been distributed over the world in recent years by the shipment of infested seed and lint and is now the most serious pest of cotton in all countries where it occurs except the United States. It was introduced into Mexico in 1914 with infested seed from Egypt and was discovered at Hearne, Texas in 1917. This and several later infestations in eastern Texas, Louisiana, Georgia, and Florida have been eradicated through the efforts of the Department. At present the insect occurs in the United States in limited areas on non-commerical wild cotton in parts of south Florida where eradication is under way and in sections of the Southwest adjoining and adjacent to areas in Mexico where eradication is difficult because of reinfestation by flight of moths. The discovery of the pink bollworm in the Lower Rio Grande Valley of Texas in 1936 is the most serious menace ever to confront the American cotton industry because of the danger of spread throughout the main cotton belt. The pink bollworm causes losses estimated at from 20 to 50 percent of the crop in other countries where it is established. The principal damage is to the bolls and the losses it causes would be largely in addition to those caused by the boll weevil.

While individually the damage caused by native insects is not as great as that of the boll weevil or the pink bollworm, the aggregate losses are large. It is estimated by the Bureau of Agricultural Economics that insects other than the boll weevil cause from 3 to 5 percent annual reduction from full yield of cotton. Some are of seasonal or local importance while other occur wherever cotton is grown in this country. The flea hopper and related insects occur throughout the cotton belt but cause the most damage in Texas. The cotton stainers and stink bugs are the most important pests of cotton in the irrigated sections of the Southwest. The bollworm, also known as the corn ear worm and tomato fruit worm, destroys squares and bolls in all areas and is a serious pest in some sections every year. The leaf aphids are also generally distributed but cause the most damage where insecticides are used for boll weevil control. Root aphids are limited in distribution to the South Atlantic States but cause serious damage to seedling cotton. Thrips occur everywhere although the relative abundance and damage caused by the several species varies in different sections. The seasonal occurence, distribution, biology, and damage of many other insects that damage cotton are also being investigated. Cotton is grown over such a large area and under such diverse conditions of climate, soil, and farm practices that innumerable problems of insect control exist in varying degrees in each state.

Plan and Progress of Work: The work is divided along the following lines of activity:

(a) Insecticides for boll weevil control: The most important contribution ever made to insecticidal control of the boll weevil was the development of calcium arsenate by this Department. Although 15 to 30 million pounds are used annually against cotton insects a much larger quantity could be profitably used. However, calcium arsenate has certain disadvantages and other materials are constantly being tested in the hope that a more satisfactory and economical insecticide for boll weevil control may be discovered. Field laboratories are located at several strategic localities for studying insecticides under different climatic, soil, crop, and other ecological conditions representing typical sections of the cotton belt. Preliminary investigations are conducted with new insecticides that become available in field cages where conditions can be carefully controlled and the work done more economically. Field studies are made in representative areas to determine the amount of damage caused by different degrees of weevil infestation, the comparative value of different insecticides for the boll weevil under different conditions, and the methods of overcoming any injurious effects of insecticides on plants and soils. Other species of insects are frequently injurious to cotton in the same fields where the boll weevil occurs and combinations of materials are being tested for the control of the boll weevil and other insects at the same time.

(b) Seasonal development, biology, ecology, and status of the boll weevil: Fundamental information on the life history, habits, status, and other factors relating to the abundance or damage caused by the boll weevil under different conditions has been the basis for developing and improving control methods. Information on the seasonal abundance and annual fluctuations in abundance and damage is of value to cotton growers as they can plan to have on hand insecticides and dusting machinery for use when needed. Climatic factors such as high and low temperatures, rainfall, and humidity are the most important in determining the fluctuations of boll weevils from year to year. Information on the number of weevils entering hibernation and surviving the winter is obtained by examinations of woods trash and Spanish moss in different sections each fall and spring, and by placing large numbers of weevils collected from cotton fields in hibernation cages to observe the percentage and time of spring emergence. Infestation records are made throughout the season in different sections to determine the abundance of weevils, the need for applying insecticides, and the effects of summer weather on weevil mortaility. Observations are made on wild and cultivated plants to note changes in the food habits of the weevils and their adaptation to plants other than cotton over a period of years. This information on weevil abundance is of great value in assisting growers to apply insecticides when needed and to prevent the waste of insecticides when not needed.

(c) Boll weevil control on sea island cotton: Sea island or long staple cotton was an important industry in South Carolina, Georgia, and Florida before the boll weevil arrived but production was discontinued about 20 years ago largely because of the excessive weevil damage. Considerable interest has been shown in recent years in the revival of this industry

but success depends upon developing satisfactory control measures for the boll weevil. The rehabilitation of sea island cotton will provide a much needed cash crop for the poorer sandy soils of the area that does not compete with other kinds of American cotton and replaces imported cotton. Weevil control is more difficult than on short staple cotton because of the longer fruiting season, slower maturity of the bolls, softer boll walls, and more luxuriant plant growth of sea island cotton. The work consists largely of testing various insecticides in field plots to determine which are most efficient, the best method and timing of applications, and the minimum dosages and number of applications needed. Experiments have shown that boll weevils can be controlled on sea island cotton by using insecticides throughout the season, and efforts are now being made to reduce the cost so that weevil control can be profitably used on the low producing land planted to sea island cotton.

(d) Varietal resistance to the boll weevil: The improvements that have been made in the varieties of cotton since the advent of the boll weevil have greatly reduced the damage by considerably shortening the fruiting period and time required for development of bolls. Comparatively few boll weevils survive the winter but their numbers rapidly increase through several successive generations until they become so abundant in the fall that a late crop is ruined. The limit in earliness and shortening the growing period has about been reached and further improvements in resistance to weevil attack will have to be made largely upon physical or other inherent characters that prevent or reduce the damage by the boll weevil. Preliminary investigations show that no varieties or strains of cotton are immune to boll weevil attack but that such characters as boll wall thickness, toughness of carpel lining, and hairiness of the leaves influence the amount of damage. Even a slight improvement in resistance to weevils that would reduce the damage by one percent would prevent several millions of dollars of losses annually. All classes of growers from the largest to the smallest would be benefited.

The work is conducted at Stoneville, Mississippi where the Bureau of Plant Industry maintains a large collection of all species and varieties of cotton for genetical studies. Plants are selected for weevil resistant characters and stocks of pure line strains maintained by self-fertilizing the flowers from desirable plants and planting the seeds from each plant separately.

(e) Natural enemies of the pink bollworm: Introduced pests, such as the pink bollworm, are often more serious in a new environment because their natural enemies are not present, and one of the most economical and effective means of control is to restore the balance by the introduction of natural enemies. Many species of parasites occur in other countries and introduction of the more promising parasites from Europe, Asia, Africa, and Hawaii has been made in cooperation with the Division of Foreign Parasite Introduction. A new species collected in Japan will be available this year and other species will be obtained from time to time. A special parasite breeding insectary is used at Presidio, Texas for handling and rearing the pink bollworm parasites in

sufficient quantities for liberations in Texas, Mexico, and Puerto Rico. Reduction in pink bollworm damage through colonizing parasites in Mexico will be of benefit to this country in reducing the danger of spread. Successful methods have been developed for the economical rearing of most of the parasites on hosts other than the pink bollworm. Large colonies of four species of parasites have been liberated and recoveries made in the fields during the same season.

(f) Insecticides for pink bollworm control: Insecticidal control of the pink bollworm is urgently needed because of the seriousness of this pest and the losses it would cause in case it should become established throughout the cotton areas of the United States. Experiments with insecticides in this and in other countries have not been successful to date because the eggs are laid under the bracts of the bolls and in other protected places, and because the worms feed entirely within the bolls or squares where they are difficult to reach. The importance of the pink bollworm as a pest justifies continuing investigations with new insecticides and new methods of application of standard insecticides until the possibilities of control are exhausted. New insecticides are constantly being discovered and the new dusting and spraying machinery that gives better coverage should be tested against the pink bollworm. Tests with new insecticides are first made under laboratory conditions and the more promising materials then tested in cages and in small field plots. The work to date indicates that the fluorine compounds will be more effective against the larvae than the arsenicals, nicotine, rotenone, phenothiazine, or other insecticides that have been tested. Reductions up to 75 percent of the larval populations have been secured in some of the field tests.

(g) Cultural practices and varietal resistance for control of the pink bollworm: In all countries the most effective measures for reducing the pink bollworm damage and of producing cotton in its presence has been the use of cultural practices. Where eradication is not feasible cultural practices are useful in lowering the population and lessening the danger of spread to new areas. Cultural practices are directed against the overwintering larvae that remain in the fields after the crop is harvested by (1) destruction of the larvae remaining in the crop debris, (2) increasing the winter mortality of the hibernating worms, and (3) by spring treatments so that surviving worms will be killed or caused to emerge before cotton is available. Deep plowing and thorough coverage of infested bolls followed by immediate irrigation early in the winter has been found to kill 80 to 90 percent of the worms. The proper timing of spring irrigation and dates of planting cotton have been found of benefit in causing the moths to emerge before cotton is available for food. Improvements have also been made in machinery for cleaning the fields that reduce the cost of this operation.

No varieties of cotton have been found that are immune to pink bollworm attack but the varietal characteristics that have been successfully used against the boll weevil are of great value in

evading part of the damage through early maturity of the crop. Varieties developed for boll weevil conditions have been introduced into the pink bollworm infested area of the Big Bend and are greatly liked by the growers. A large field cage covering three quarters of an acre is used for dates of planting tests to prevent infestation from outside moths. The information developed from these investigations has been extensively used in the cleanup and control campaigns. It has also been of value to growers in producing larger yields and improving the quality of the cotton under pink bollworm conditions in the Big Bend of Texas. Considerable progress has been made but new problems are constantly arising, and these investigations should be continued over a series of years to work out details for different conditions that will be the most practicable for use by growers.

(h) Seasonal development, biology, ecology, and status of the pink bollworm: Information on the seasonal development, biology, ecology, and status of the pink bollworm is essential for developing control and eradication measures. Investigations should be continued over a period of years to evaluate control recommendations under average conditions for different localities. Records are made of the seasonal development and status of the pink bollworm in a number of representative fields in the Big Bend area to determine the variations between fields and the seasonal variations within fields in order to discover the factors causing these fluctuations. This project is closely associated with the work on cultural practices and is used to discover the most vulnerable points against which control measures can be directed. Records are made of the infestation and survival in several Valleys of the Southwest where the pink bollworm occurs for comparing the effects of temperature and rainfall on the abundance and winter mortality. This work increases the efficiency of the cleanup programs of the Department and farmers by providing information on the time and number of pink bollworms entering hibernation in various fields so that these may be given first consideration.

(i) The cotton flea hopper and related insects: This group of insects are generally distributed over the cotton belt and in some sections are the most important pests of cotton. They normally feed on many species of wild and cultivated plants and migrate from these to cotton in enormous numbers. They suck the juices from the plants causing the young squares and bolls to drop and abnormal growth of the plants. Much of the failure to produce crops of cotton that was previously attributed to the weather and other physiological conditions has been found to be caused by these insects. Considerable progress has been made in the control of these insects during recent years, especially for the conditions of southern and eastern Texas where satisfactory dusting schedules have been developed. These insects occur over such a wide range of climatic and soil conditions that control measures should be tested under various conditions. Investigations are under way at Waco, Texas which is representative of conditions in approximately one-third of the State of Texas, and in the Salt River Valley of Arizona representative of the irrigated sections of the Southwest.

Special attention is being given to dusting with airplanes in Arizona because of the difficulty of covering the rank growing cotton and the interference of irrigations with the operation of ground machinery. The effects of strip cropping and other conservation measures on the abundance of the flea hopper are being investigated. Varieties of cotton representative of different growth habits and other inherent characteristics are being tested for attractiveness and response to insecticidal treatment. In the several million acres where Texas root rot is prevalent control of these insects is especially important so as to protect the early squares and bolls before the plants are killed by the root rot disease.

(j) Stainers and stink bugs injurious to cotton: Stink bugs and stainers are native insects that attack many plants besides cotton. They are generally distributed but the stainers cause the greatest damage to sea island cotton in Florida and the stink bugs in the irrigated Valleys of the Southwest. Their feeding on the bolls causes them to drop from the plants or to produce matted, stained fibers of poor quality, often causing reductions of 25 to 50 percent of the yeild. It is also estimated that the quality of the lint harvested in Arizona is reduced by one full grade, or $5 per bale, by this group of insects. These insects are difficult to control by insecticides or through cultural practices and crop rotations because of the great number of alternate host plants. Recent experiments in dusting with mixtures of paris green and sulphur have shown great promise for control but further information is needed on the populations of insects that require control measures, the minimum dosages, and number of applications for the most economical gains under different conditions. Cotton growers of the Southwest have cooperated fully with the Department in developing control measures.

(k) Bollworm investigations: The cotton bollworm, also known as the corn ear worm and tomato fruit worm, is another native insect that damages a number of crops. It is generally distributed and as a cotton pest is frequently ranked next in importance to the boll weevil. The worms feed on the squares and bolls and some damage is caused to cotton in every section of the United States while at times severe outbreaks destroy practically the entire crop on some farms. The bollworm is frequently the most important pest of cotton over large areas of Texas and Oklahoma where climatic conditions are favorable and large acreages of grain sorghums provide suitable alternate host plants. It has been estimated that the bollworm causes an average of 2 to 4 percent reduction in yeild or 16 to 32 million dollars' damage to cotton annually. Control is difficult or impossible after the bollworms reach the inside of squares and bolls, and insecticides must be applied soon after the eggs hatch to be effective. Cultural practices and crop rotations are of some value but do not give adequate protection to cotton. Investigations of control by insecticides are conducted under field conditions in cooperation with growers as cage tests have not been found as satisfactory for the bollworm as with other cotton insects. The effects of strip cropping and conservation measures on bollworm abundance are being investigated in cooperation with the Soil Conservation Service at Waco, Texas.

(l) Leaf aphids injurious to cotton: The use of calcium arsenate to control the boll weevil has been found to increase the number of leaf aphids but the reasons for this have never been satisfactorily explained. At least three species of leaf aphids attack cotton and other crops and the increased use of cover crops for soil enrichment from which the aphids migrate to cotton is causing the leaf aphid problem on cotton to become more acute. Besides direct reduction in yield of cotton by sucking the juices and lowering the vitality of the plant, the aphids secrete a honey dew in which a sooty mold develops that covers the plant and soils the lint. Many farmers hesitate to use insecticides for boll weevil control because of the aphid damage, and a successful method of reducing or preventing damage by leaf aphids would also materially increase the amount of insecticides used for the boll weevil.

The effect of arsenicals and other insecticides used for boll weevil control on the parasites and predators of leaf aphids will be studied. Preliminary tests have indicated the possibility of mixing an insecticide with calcium arsenate to prevent the increase of aphids following its use, and further investigations will be made to determine if this can be developed for practical use. Calcium arsenates of varying chemical and physical qualities will be tested in an effort to find a calcium arsenate effective against the boll weevil without increasing aphid abundance. Investigations have shown no varieties of cotton that are immune to aphids but some strains from the same parents are more resistant or tolerant than others. The possibility of developing an aphid resistant variety appears good and work will be continued at Stoneville, Mississippi in connection with boll weevil resistant studies.

(m) Root aphids injurious to cotton: Root aphids are sucking insects that feed entirely under ground on the roots and stems of the cotton plant. Their presence is manifested by stunted unhealthy plants which often die and leave poor stands or necessitate replanting. This results in losses of seed and fertilizer and delays the crop so it is more susceptible to late season weevil damage. The feeding punctures on the roots also increase the susceptibility of cotton to seedling diseases. At least three species of root aphids are known to attack cotton in the Coastal Plains of Virginia, the Carolinas, Georgia, and Florida, and surveys are needed to determine their distribution in other areas. Many other cultivated crops and weeds are attacked and the problem is further complicated by the ants that feed on the honey dew secreted by the aphids. The ants move the aphids to the roots of new plants and protect them in compensation for their food. In the spring when cover crops are turned under or weeds killed by cultivation the aphids concentrate on cotton. The increased use of soil building crops has intensified root aphid damage to cotton. Preliminary experiments have shown that direct control by insecticides or repellents mixed with fertilizers or applied to the roots is difficult and a more promising approach seems to be through control of the attending ants by poison baits and selective rotation of crops. Information is needed on control to reduce the losses to cotton growers and to assist the Soil Conservation Service in developing crop rotations and the selection of soil building plants that are less susceptible to root aphid damage.

(n) Thrips injurious to cotton: Thrips are omnivorous feeders and cotton is an incidental host plant. They migrate to cotton from small grains, cover crops and other plants and considerable damage is caused to cotton by the dozen or more species of thrips that feed in the terminal buds and on the tender leaves. Thrips occur everywhere and although severe outbreaks are sporadic, large acreages are entirely ruined at times. Moderate infestations cause abnormal branching of the plants and reduce the crop from 2 to 4 bolls per plant. In California thrips are the most serious cotton pest and attack the plants late in the season, sometimes causing defoliation and losses of 25 percent or more of the crop. Studies are needed on the biology, habits, and host plants of the various species attacking cotton as a basis for developing control measures.

(o) Seasonal occurrence, distribution, damage, and biology of various cotton insects: Investigations under this project include all cotton insects being studied that are not included in other work projects. There are dozens of insects that are at times serious pests and hundreds that occasionally injure cotton. Some of these extend throughout the entire cotton belt while others are limited in their distribution. The cotton leaf worm is an important species which does not overwinter in this country but infestations are started each spring by the moths that fly in from the tropics. When infestations occur early in the season they often spread throughout the cotton belt and require millions of dollars for control.

(p) Dissemination of information to the public regarding cotton insects and their control: Numerous requests for information in regard to cotton insects and their control are received from all parts of the country and from representatives of many foreign countries and others interested in cotton production. Information is also furnished entomologists, experiment station, extension service, and other state officials of the cotton growing states, and representatives of manufacturers of insecticides and dusting equipment. Timely information on the abundance of insects, outbreaks of unusual interest, and methods of control is furnished growers and state officials through press and radio releases. The results of research are made public through scientific journals and bulletins of the Department. The furnishing of this information is a service closely associated with the research activities and is a normal function of the operations.

(q) Importation of natural enemies of cotton insects: Certain of the important insects which attack our cotton are introduced and other species native to this country are related to forms occurring in other cotton-producing countries. Natural enemies contribute to the control of important pests and effort is made to locate beneficial forms that occur in other countries, secure information on their behavior and import those which are useful. At present parasites of the pink bollworm are being collected and reared in Korea for importation and liberation in areas where this pest occurs in the United States. Exploration work is also under way in parts of South America to determine the desirability and practicability of importing any natural enemies of weevils, cotton stainers, and stink bugs that occur there.

(q) PINK BOLLWORM AND THURBERIA WEEVIL CONTROL

Appropriation Act 1941	$526,800
Budget Estimate, 1942	526,800

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Pink bollworm control operations:			
(a) Supervision of treatment and movement of cotton or cotton products as required by Federal quarantine on pink bollworm....	$168,273	$192,000	$192,000
(b) Inspection within regulated area to determine status of pink bollworm....	33,783	34,000	34,000
(c) Inspection outside regulated area to determine possible presence of pink bollworm..............	110,167	122,900	122,900
(d) Cleanup operation for control and eradication of pink bollworm...........	53,396	90,977	90,977
(e) Field clean-up for suppression of pink bollworm in Lower Rio Grande Valley.....................	456,667	---	---
(f) Vehicular inspection to determine compliance with quarantine on pink bollworm..................	24,819	30,600	30,600
(g) Eradication of wild cotton in Florida for protection against infestation of pink bollworm.	53,129	53,515	53,515
(h) Thurberia weevil control.	2,644	2,808	2,808
Unobligated balance.............	6,730	---	---
Total appropriation	909,608	526,800	526,800

WORK UNDER THIS APPROPRIATION

General: This item provides for activities concerned with the prevention of artificial spread of the pink bollworm from the infested area, including the enforcement of the Federal domestic quarantine; control operations in the area along the Mexican border contiguous with the infested area in Mexico; eradication activities in isolated points where infestation is detected; inspections to determine presence of the worm; surveys and control operations in Mexico in cooperation with the Mexican Government or local Mexican authorities; and other related work to protect the cotton culture of the United States from this pest. The item also provides for the enforcement of the quarantine on the Thurberia weevil.

The pink bollworm is the most destructive pest of cotton and is generally established in all important cotton countries, except the United States. In the United States it occurs in limited areas in Texas, New Mexico and Arizona adjacent to infested sections in Mexico and to a limited extent in non-commercial wild cotton growing on the Keys and part of the mainland of southern Florida. In times past it has gained limited establishment in other sections of the United States from which it has been eradicated. Such isolated areas of infestation occurred in northern Florida, southern Georgia, Louisiana, Texas and Arizona. It is not believed possible that the insect can be eradicated from the infested areas in sections adjacent to sources of infestation in Mexico by action taken by our country alone. The occurrence of these infestations is a continual menace to the cotton culture of the United States. The work now under way is, therefore, directed (1) to the eradication of the infestation in southern Florida, including the elimination of non-commercial wild cotton to remove this source of possible spread; (2) the eradication of the isolated infestation in the Santa Cruz and Salt River Valleys of Arizona; (3) the enforcement of regulatory measures to prevent artificial spread from known infested sections; (4) carrying on, in cooperation with States where infestation occurs and Mexico, suppressive measures to reduce the population in areas of infestation along the Mexican border to lessen the possibility of natural spread; and (5) scouting to determine possible infestation in new areas and the status of the pest in known infested areas. These activities, which are of a continuing nature and are of interest to the entire cotton producing area and all its associated interests, are divided into several work projects which are discussed in the following sections:

(a) Supervision of Treatment and Movement of Cotton and Cotton Products as Required by Federal Quarantine on Pink Bollworm:

Objective: To prevent the spread of the pink bollworm to new areas, and to prevent its building up in known infested areas by the supervision of processing plants and other control measures.

The Problem and its Significance: The pink bollworm of cotton develops within the cotton boll. The mature larvae feed principally upon cotton seed in the boll. They also hibernate in the seed. In the ginning of seed cotton, quite a number of seed get into the bale of lint. The cotton seed, therefore, must be given major consideration in the control and eradication of the insect, which is mainly disseminated through the movement of cotton seed.

A process of sterilization of the cotton seed, as a continued process of ginning, has been evolved whereby the seed is heated sufficiently to kill any pink bollworms therein, but not hot enough to injure the germination of the seed. In some instances where this procedure cannot be followed, or the situation does not warrant it, the seed is sent direct to oil mills where it is sterilized before milling. The baled cotton lint, which carries more or less seed, is also sterilized, given vacuum fumigation, or compression, as conditions warrant, as a precaution against spread of the insect.

Supervision of the treatment and movement of cotton and cotton products as required by federal quarantine on pink bollworm incident to the control and extermination of the insect is now in effect in the infested areas of Arizona, New Mexico, and Texas, comprising 71 Counties.

Plan of Work: The area in which the supervision of the treatment and movement of cotton and cotton products is required is divided into six districts and thirty sub-districts for administrative purposes. Inspectors are stationed in these districts and sub-districts in proportion to the amount of work involved. Inspections are made each day of each of the cotton gins and other processing plants to insure compliance with the regulations under the federal quarantine.

This work, during the fiscal year 1940, required the supervision of the ginning of 765,235 bales of cotton at 448 gins; the sterilization of 343,382 tons of cotton seed as a continuous process of ginning; the sterilization of 276,174 tons of cotton seed at 41 designated oil mills; the compression of 610,448 bales of lint at 12 compresses; the roller treatment of 17,885 bales of cotton linters, and the fumigation of 355 bales of Mexican linters arriving in the United States.

There is a total of 501 cotton processing plants within the infested regulated areas, requiring daily inspection and supervision to enforce compliance with the federal quarantine.

Such inspections and supervision are done at an average cost of $384 per plant per annum.

(b) Inspection within Regulated Area to Determine Status of Pink Bollworm.

Objective: To make careful and thorough inspection within the regulated areas to determine the degree of infestation. This work is essential in obtaining information for use in promulgating regulations under quarantines; establishing control methods, or for the release of areas from quarantines.

The Problem and its Significance: All infested areas are placed under quarantine, and the cotton produced therein is controlled by certain regulations to prevent the spread of the insect into non-infested areas. These areas are a constant source of spread of the insect and must, therefore, be given periodic inspections to determine the degree of infestation, whether it is building up or decreasing, in order that control measures may be adjusted in accordance with the degree of infestation revealed by such inspection.

Plan of Work: In determining the degree of infestation within a regulated area, inspectors are sent first to the areas of earliest maturing cotton to make inspection of blooms by hand to determine the early emergence of the carry-over infestation, if any. Such inspection is conducted by from four to eight inspectors for a period of from two to three weeks. As the ginning season begins, gin trash inspection machines are sent to the area. These machines separate the worms from the gin trash. The trash comes from the seed cotton in the process of ginning. Any pink bollworms that are in the fields might be contained in the trash. In separating the trash, the larvae of the pink bollworm are readily exposed to view in an almost negligible quantity of trash. Trash from a sufficient number of bales of cotton ginned within the regulated area is inspected to determine the degree of infestation. It is important in making such inspections to inspect a sufficient quantity of trash to give as accurately as possible the percentage of infestation within the regulated area. During the fiscal year 1940, 38,245 bushels of gin trash were inspected within a regulated area in Arizona, resulting in the finding of 94 pink bollworm specimens. This indicated a light infestation still present in the area. This work required the use of six gin trash inspection machines inspecting for an aggregate of 296 days. Had a superficial inspection been made of the trash in the area, no infestation would have been discovered, but by continuing until a thorough inspection had been made, it was revealed that the area was still infested and was not ready for quarantine modifications or release from regulations. Similar inspections are conducted in each of the regulated areas comprising the 71 counties under quarantine regulations in the states of Arizona, New Mexico, and Texas.

This inspection is done through the operation of gin trash inspection machines. Approximately 70,000 bushels of trash are collected and inspected. The cost of collecting and inspecting this trash amounts to $.50 per bushel. (Cost data show that gin trash can be inspected much cheaper within regulated areas than it can be inspected on the outside because the outside inspection involves greater territory travel, longer trash hauls, etc.)

(c) Inspection Outside Regulated Area to Determine Possible Presence of Pink Bollworm:

Objective: To inspect all cotton areas outside the present known infested areas that are suspected of being infested with pink bollworm in order to locate these while still in the incipient stage. This results in the application of control or eradication measures before the infestation is able to build up. This often results in absolute eradication of the pink bollworm.

To make intensive inspection for the pink bollworm in any areas adjacent to known infestations, and to make a general inspection of as great a portion of the cotton belt as practical, giving particular attention to points of concentration of cotton seed and other cotton products.

The Problem and its Significance: This work began in the summer of 1917 in the United States when it was learned that cotton seed from an infested district in Mexico had been shipped to certain oil mills in this country the previous year. Inspection has continued every year since the date mentioned, although important developments have taken place in the methods of inspection.

Within the past few years the infested area in the United States has greatly increased. Certain of these infested areas are adjacent to other non-infested cotton producing areas. It, therefore, is essential that intensive inspection be continued in the non-infested cotton producing areas lying immediately adjacent to those areas known to be infested.

Plan of Work: Inspection for the pink bollworm begins with the inspection of gin trash as soon as ginning begins in sufficient volume. The principal efforts are put forth in areas thought most liable to become infested, such as near the Mexican border, or infested areas in the United States.

Periodical gin trash inspections are carried on in other parts of the cotton belt as a further precautionary measure. Most of the inspection work is done with the aid of a gin trash inspection machine. These machines are so constructed as to separate any pink bollworms from the gin trash. The gin trash is separated from the seed cotton in the process of ginning. This work is supplemented by the collection and preservation of green cotton

bolls for laboratory inspection from such areas as are thought to be in danger of becoming infested but do not have sufficient ginning to make inspection of gin trash practical. A certain amount of field inspection is conducted outside of the regulated areas, where the infestation must be traced to a definite field of growing cotton.

The plan of operation of inspection, therefore, consists of three distinct methods: (1) inspection of gin trash through the use of a gin trash inspection machine mounted on truck chassis, which makes it easily transported from one locality to another; (2) by the collection of green bolls and preserving them for laboratory inspection, and (3) by field inspection for the purpose of determining the particular fields infested.

This inspection is done through the operation of twenty-five gin trash inspection machines and crews for a period of four months during the ginning season, to inspect approximately 100,000 bushels of gin trash. The cost of collecting and inspecting this trash amounts to $1.00 per bushel. Approximately 325,000 green cotton bolls are collected, preserved and inspected, the cost of this work amounting to $.50 per thousand. Approximately 425 man days are devoted to field inspection. (The reason approximation is used here is because this work varies in accordance with the amount of suspected territory to inspect, seasonal and crop conditions, and upon the finding of territory not hitherto infested.)

(d) Clean-up Operations for Control and Eradication of Pink Bollworm:

Objective: The most effective method of eradication of the pink bollworm has been found from experience to be that of inaugurating clean-up measures, consisting of collecting and burning all particles of cotton capable of harboring the pink bollworm, immediately after the discovery of the insect; to be followed by the non-production of cotton in the infested area for a period of years.

In the control of the insect, the clean-up measures result in greatly reducing the abundance of insects by the collection and burning of the crop residues in which the insect hibernates. The destruction of such material considerably reduces the opportunity for the pink bollworm to go into hibernation and later emerge to infest a new crop.

The Problem and Its Significance: In certain infested areas, on account of climatic or other reasons, eradication is not possible, but in order to reduce the pink bollworm population and to prevent it from building up, certain control measures are necessary in addition to the treatment of the cotton and its products through the sterilization of seed, compression of lint, and by collecting and burning the crop residue after harvest of the crop. This process greatly reduces the pink bollworm population, thereby preventing a large number of insects being carried over in the

infested fields to infest the new crop the following year. There are two infested areas in semi-tropical parts of Texas and Arizona - namely, the Lower Rio Grande Valley in Texas, and the Salt River Valley in Arizona, - where the climatic conditions are such as to permit the cotton plants to produce fruit throughout the year. If the stalks are cut after harvest, they immediately sprout from the stubs, and will produce cotton again during the winter months. Also seeds falling sprout readily. Under such a situation, ideal conditions are set up for the continuous propagation of the insect.

The most heavily infested section in the United States is in the Big Bend area of Texas. Cotton heavily infested with pink bollworm in Mexico is separated only by a little more than the width of the Rio Grande from the growing cotton in the United States, infestation being heavy on both sides. A general program of suppression and control is maintained in this area on the American side of the border. This includes field cleanup and other operations to reduce the infestation and hazard of spread because of the occurrence of large numbers of moths and worms.

Plan of Work: Clean-up of cotton fields in the Big Bend area of Texas consists of the cutting and piling of the stalks and the raking up of the fallen material and burning the lot. This is then followed by delayed planting of the next crop, and other control measures. Such work has resulted in a marked decrease in pink bollworm infestation in this area. In the infested areas in the Lower Rio Grande Valley District of Texas and the Salt River Valley District of Arizona, control methods indicate that the insect can best be controlled in these two areas by destroying the cotton plants immediately after the harvest of the crop. This destruction of the commercial cotton after harvest takes away from the insect its host plant and prevents its further propagation during the current crop. However, the existence in these two areas of stalks sprouting from stubs, abandoned fields, random cotton plants along ditchbanks, ends of fields and growing among other crops, affords an ideal breeding ground for the propagation of the pink bollworm throughout the winter and spring months when no commercial crop is being grown. Thus, as the next commercial crop begins to put on fruit, there would be well established a large number of insects that would have been produced on the volunteer cotton plants in the area. It is, therefore, essential to prevent the maturing of fruit on this volunteer cotton in order to effect a control leading to the complete eradication of the insect. This work is done by grubbing out with hand labor all cotton plants in these areas to prevent their producing fruit.

This work will be done by cleaning the cotton residue on 3,000 acres in the Big Bend area at a cost of $3.00 per acre, 2,500 acres in the Salt River Valley at a cost of $5.00 per acre, 2,000 acres in the Lower Rio Grande Valley at a cost of $3.50 per acre and the grubbing out of volunteer cotton, stub cotton and abandoned fields in the two semi-tropical areas in Arizona

and Texas on 50,000 acres at $1.25 per acre.

(e) Vehicular Inspection to Determine Compliance with Quarantine on Pink Bollworm:

Objective: To inspect vehicular traffic and pedestrians to determine compliance with the quarantine on pink bollworm.

The Problem and its Significance: This project is largely supplemental to quarantine enforcement. It was evident that it would be very detrimental to the pink bollworm control and eradication program for infested material to be taken out of the regulated areas indiscriminately by either commercial handlers, producers, cotton pickers, or others.

A control over the movement of quarantined products from the infested areas by rail, express and boat is controlled through permits, but on account of the development and improvement in highways, and on account of the large areas now under quarantine, supplemental protection must be inaugurated to prevent the movement of infested material into non-infested areas.

Plan of Work: Vehicular inspection stations are conducted at strategic points leading out of the quarantined districts so as to inspect as great a portion of cotton and cotton products moving under certificate as possible.

In other areas the highways are patrolled by inspectors to intercept any truckers or others attempting to move any cotton or cotton products out of the quarantined areas without permit.

The work under this project will be accomplished by the maintenance of two traffic inspections in the Lower Rio Grande Valley of Texas during the cotton harvest season.

(f) Eradication of Wild Cotton in Florida for the Protection Against Infestation of Pink Bollworm:

Objective: It is the purpose of this project to eradicate the wild cotton from south Florida, thereby removing a source of infestation endangering the main cotton belt of the southeastern states.

The Problem and its Significance: The discovery of pink bollworm infestation in wild cotton and dooryard ornamental cotton plants in south Florida in 1932 constituted a menace to the cotton industry of the southeastern states. Surveys immediately following the discovery of infestation revealed infested wild cotton throughout southern Florida, including the Florida keys. These plants range from small two or three leaf seedlings to trees several inches in diameter, and from 15 to 20 feet in height. The entire southern area of Florida was covered with plants in all stages of development, and in many seemingly inaccessible localities. The pink bollworm infestation in this cotton was

as high as 40 percent when discovered in 1932.

Plan of Work: Eradication measures were instituted immediately after discovery of the insect by removing all wild cotton plants along the highways and ornamental cotton from dooryards, and such other accessible places as would allow the infested bolls to be carried by human agencies to non-infested cotton localities. Further eradication measures included the survey of the keys and swamps to locate the cotton, followed by cleanup crews who took out the plants and burned them. In order to complete the job, it is necessary to re-clean the originally cleaned areas the following year to remove the seedlings and sprout cotton originating from the mature plants removed the year before. Since the area in which this cotton grows is tropical, the plants grow throughout the year. The fallen seed may sprout the next year, or may not sprout for several years. This retards the immediate eradication of all of the plants within a short time. The success, however, in eradicating the pink bollworm in domestic cotton in northern Florida and southern Georgia is directly traceable to the fact that the pink bollworm infestation in wild cotton in southern Florida has been reduced from infestations as high as 40 percent to a general average infestation of less than 1/10 of one percent.

The total area on which these wild cotton plants grow is 17,500 acres. The area is principally swamp land with heavy vegetation on the high ground. The wild cotton grows among this rank vegetation. Cost data collected over a period of years show that this work can be done at a cost of $2.05 per acre. Careful surveys of adjacent swamp and jungle growth must be made over an additional area of about 50,000 acres each year to determine whether this wild cotton has spread to new territory.

(g) Enforcement of the Quarantine on Thurberia Weevil:

Objective: This project provides for the administration and enforcement of the Federal quarantine on account of the Thurberia weevil, which quarantine regulates the movement of cotton and cotton products from the infested area in Arizona where this pest is known to occur.

The Problem and Its Significance: The Thurberia weevil is a native variety of the Mexican boll weevil, and occurs in limited areas in the State of Arizona and parts of Mexico. Under natural conditions this native insect lives on the wild Thurberia plant. With the production of cultivated cotton in this area, it has become attracted to this crop. The weevil has demonstrated capacity to breed in cultivated cotton, and, because of its ability to live under arid conditions, is a serious menace to cotton grown under semi-arid conditions. Thus, if it is allowed to become established, it might become equally as injurious to the cotton areas of the semi-arid belt as the common boll weevil has to the cotton areas in the humid belt.

Plan of Work: The quarantine regulations on Thurberia weevil are closely related to the control measures used against the pink bollworm. These regulations require supervising the handling, treatment and movement of cotton, cottonseed and other articles likely to carry the Thurberia weevil into uninfested regions. An inspector is stationed in this quarantined area to inspect daily the processing plants. During the fiscal year 1940, there were inspected 12,682 bales of cotton, 10,828 compressed and 6,341 tons of seed milled.

There are 5 gins, 1 compress and 1 oil mill handling cotton and cotton products from this infested area. These plants are inspected daily.

SUPPLEMENTAL FUNDS

Direct Allotments

Projects	Obligated 1940	Estimated obligations, 1941
Emergency Relief Appropriation Act of 1939:		
Locating and destroying Thurberia plants.	$59,180	---
Wild cotton eradication	50,281	---
Emergency Relief Appropriation Act of 1940:		
Wild cotton eradication.................	---	$42,564
Total, Supplemental Funds (direct allotments)	109,461	42,564

(r) BEE CULTURE

Appropriation Act, 1941..............$83,000
Budget Estimate, 1942................ 83,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Bee culture and apiary management..................	$82,172	$83,000	$83,000
Unobligated balance...........	828	---	---
Total appropriation.....	83,000	83,000	83,000

WORK UNDER THIS APPROPRIATION

General: This item provides for investigations on the habits and management of bees to make the production of honey and wax more profitable and to facilitate the pollination of fruits and vegetables and forage crops by the use of honeybees; and for the issuance of permits and inspections of adult honeybees imported into the United States under the Act of 1922 governing the importation of adult honeybees. This is the only specific appropriation made by the Federal Government which provides assistance or aid to the beekeeping interests in the United States, the annual value of which may be conservatively estimated at $100,000,000. Only fourteen states carry on investigations in the field of bee culture and these activities are coordinated with those done under this appropriation. The states look to the United States Department of Agriculture to supply them the necessary information regarding the management of bees, control of their diseases, and satisfactory and effective handling of them in the pollination of plants and production of honey and wax.

Headquarters for the work carried on under this item are maintained at the laboratory at Beltsville, Md., where general investigations are conducted as well as those concerned with problems affecting beekeeping in the Eastern States. Main field laboratories are located at Laramie, Wyo., Baton Rouge, La., and Davis, Calif., and a sublaboratory at Madison, Wis., to investigate problems peculiar to these regions and also study the effect of regional conditions on problems occurring throughout the United States. Investigations on certain special problems are also carried on in cooperation with state agencies in Arkansas, Iowa, and Texas.

Objective: To devise methods that will make the production and marketing of apiary products more profitable to the beekeeper and that there may be an adequate number of honeybees available at all times in the principal agricultural areas to insure the pollination of orchard, garden, and farm crops.

The Problem: Small colony production and the small price paid the beekeeper for honey and beeswax and for the rental of bees for pollination make it desirable that methods of apiary management be improved so that the cost of honey production may be lowered and that a better quality of honey be produced. Various factors contribute to the low average per colony production, among which may be mentioned winter losses of colonies, ravages caused by bee diseases, the keeping of inferior stocks or strains of honeybees, poor management, the use of unsatisfactory methods of processing and packing honey, etc. These factors, all of which affect the beekeeper directly, result indirectly in a more serious loss to agriculture in that they have a bearing on the number of honeybees kept in areas where they are needed to pollinate important agricultural crops, such as orchard and small fruits, forage plants, greenhouse crops and other plants. In some areas the absence of

bees has a close relation to the perpetuation of plants which play an important and necessary part in soil conservation.

Significance: The annual production of honey in the United States amounts to about 120,000,000 pounds; figured on a per capita basis, the consumption is very small and there is no reason why honey production could not be increased and why many more families located in rural and suburban areas should not keep enough bees to supply their own table and to have some surplus for sale as a cash crop. Beekeeping is important in the United States not so much because thousands of persons depend on honey production for a livelihood but because bees are the only pollinating insects whose numbers and locations may be controlled and made available in the areas where wild pollinating insects are deficient in numbers. It is very conservatively estimated that the value of bees for pollination is 5 to 10 times greater than the value of the honey produced. Well-qualified authorities generally agree that owing to changes in agriculture, wild pollinating insects are very much on a decline and that the profitable growing of many farm crops and plants are dependent to a large extent on honeybees. It would be dangerous, therefore, if there were any diminution in the number of honeybees in the hands of beekeepers. The average fruit grower and farmer does not take kindly to keeping bees for the purpose of pollinating his own crops.

Plan and Progress of Work: The work falls under six broad headings as follows:

(a) Dissemination of information on the care and management of bees and other questions on bee culture, including general information:

There is a tremendous interest in beekeeping. Those who keep bees have many questions to ask, those who wish to keep bees fall in the same category, and many schools and institutions are interested in bees for one reason or another. Such inquiries are taken care of through correspondence and through the publication of bulletins, articles in journals, periodicals, and newspapers. Not only beekeepers but State Departments of Agriculture depend on the services of this Bureau in the diagnosing of difficult and unusual cases where diseases of bees are involved, averaging about 1,000 a year. Talks are given to beekeepers and scientific organizations as funds and time permit, most of the attendance at beekeepers' meetings being without cost to the Government other than salary. Work is under way of preparing a series of Farmers' Bulletins covering the principal beekeeping regions in the United States.

(b) Diseases, poisoning, and other abnormal factors affecting bees: Various contagious diseases of bees are widely scattered over the United States, and most States employ apiary inspectors in an effort to control bee diseases. This work is entirely research and the principal effort is being placed on a study of American foulbrood, the most serious of all bee diseases. In cooperation with the

Agricultural Experiment Stations of Arkansas, Iowa, Texas, Wisconsin, and Wyoming, strains of honeybees are being tested for susceptibility or resistance to this disease. Strains showing resistance are isolated and mated and through systematic line breeding the percentage of daughters which show resistance has been materially increased in several strains. Some strains have proved so superior that a limited number of queens has been made available to State agencies for further breeding and testing.

The effect of insecticides on honeybees is being studied, a problem of considerable importance in some areas. Causes of heavy losses of bees in Utah are being studied; beekeepers in that State are of the opinion that poisonous baits used to control grass-hoppers are responsible.

(c) Enforcement of the Honeybee Act of 1922: Under this project permits are issued for the importation of honeybees in the United States and all imported shipments are examined for the presence of *Acarapis woodi*, a parasitical mite found in European countries but so far has been excluded from the United States.

(d) Bee Breeding: The characteristics of various races and strains of honeybees are being studied with particular reference to biometric measurements, color, etc., in an effort to classify bees that pure lines may be isolated as the foundation for future breeding work. In conjunction with this, the technique of artificial mating of queens is being improved, the technique already producing results that make possible the rearing of almost any number of successive generations without natural matings. Work on bee breeding is of much importance in furthering the work of developing strains resistant to foulbrood and superior for honey production. The ultimate object is of course, to perfect stock highly productive, gentle, and resistant to disease.

(e) Management of bees for the production of bee products; wax, honey, propolis, venom, package, and queen bees, including studies on the behavior and psychology of bees: In conjunction with the preceding project, comparative tests are being made of the productivity of commercial strains of honeybees. Differences in excess of 100 pounds of honey per colony per year have been found among strains. Some strains which are being sold to beekeepers cannot possibly produce honey at a profit unless the season is unusually favorable for honey production. A study of the exact role played by pollen in the economy of the hive is producing unexpected results. Supplying colonies with a reserve of pollen in the fall acts as good insurance for successful wintering. The food value to bees of various pollens is being studies, along with the exact requirements of colonies, methods of feeding pollen, etc. Studies are also being made of the availability of pollen in the field and of how colonies may be manipulated to obtain the maximum amount of pollen. Methods of managing apiaries for the maximum production of package bees are being studied. There is every indication that the demand for package bees will con-

time to grow, provided package producers can supply bees at a reasonable cost and guarantee safe and timely delivery. Various phases of queen rearing are being studied and the physiology involved in the causes which bring about development of both queens and worker bees from fertilized eggs is receiving attention. Less than 200 queen breeders supply the majority of queens used in the United States and better methods in the hands of these producers should mean much to the whole beekeeping industry.

(f) <u>The inter-relationship between bees and flowers, including studies on nectar and pollen</u>: The conditions under which bees visit flowers for both nectar and pollen are being studied. It has already been shown that honeybees are highly discriminating in working first the blossoms producing the highest concentration of sugar. A big difference in sugar concentration of nectar of varieties within species has been noted. In trying to improve the productivity of various plants it is undoubtedly important that attention be given to sugar concentration of the nectar as those with the highest sugar concentration attract bees first, thus insuring pollination. The effect of the proximity of non-cultivated honey plants on commercial planting of economic plants is being studied. It has been shown that the use of certain cover crops which may be highly attractive to bees may result in decreasing the number of honeybees visiting a crop which requires pollination. Studies are being made of the exact conditions which result in nectar secretion such as atmospheric pressure, temperature, humidity, light, etc. A beekeeper has no way to judge beforehand the conditions under which a plant is apt to secrete nectar and so his search for bee pasturage is done more or less blindly. The habits of bees in storing excess pollen in the fall are receiving attention from the standpoint of apiary management and the availability of pollen as to plant sources. The work indicates that where bees are used for pollination purposes that their activities in visiting flowers may be greatly increased through the use of pollen traps on the hives.

(s) INSECTS AFFECTING MAN AND ANIMALS

Appropriation Act, 1941..................$181,500
Budget Estimate, 1942.................... 181,500

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Investigations on insects affecting man....................	$63,111	$68,173	$68,173
2. Investigations on household insects..........................	14,417	14,475	14,475
3. Investigations on insects affecting animals................	103,374	98,852	98,852
Unobligated balance...............	598	- - -	- - -
Total appropriation.........	181,500	181,500	181,500

WORK UNDER THIS APPROPRIATION

General: This item provides for investigations on insect pests attacking man or injuring him by carrying diseases, including those insect pests which annoy him in his habitation or destroy household supplies, fabrics, etc. It also provides for investigations on insects as pests of animals and as carriers of animal diseases, and also for the development of methods for their control or eradication. Activities are carried on independently or in cooperation with the U. S. Public Health Service, the Bureau of Animal Industry, and Fish and Wildlife Service. The Bureau of Entomology and Plant Quarantine, however, is responsible for the investigations on insects. The work is divided along the following lines of activity.

Project 1. Insects Affecting Man:

General: The work under this project is concerned with investigations on insects which annoy man by direct attack or injure him by carrying diseases. Only a few of the more pressing problems are now being studied. These are discussed in the following sections:

(a) Mosquito Investigations:

Objective: To develop new and more effective methods of control of the more important pest and disease-carrying mosquitoes, applicable to the widely varying conditions found in different regions.

The Problem and its Significance: Mosquitoes as a class are the most important insect pests known to man. They are responsible for carrying such dreaded diseases as yellow fever, malaria, dengue fever, and are strongly suspected of having a direct relationship with human sleeping sickness and encephalomyelitis of horses and mules. There are many different kinds of mosquitoes and no one control measure is equally effective for all kinds. Although the habits of some of the commoner forms are fairly well known and means for control of these species have been developed, the habits of many kinds are known only in a general way and effective controls are not yet developed. Even with the commoner species, methods of control depend on local conditions, and one well established method in one region might not be applicable to another. The planning for control campaigns requires technical assistance and at present the requests for advice can only be partially met. The investigations under way are conducted from Portland, Oregon; New Smyrna, Florida; and Orlando, Florida. Those studies in the Northwest are concerned largely with mosquitoes that breed in flood water and, to some extent, those breeding in snow water in mountainous areas. Those in Florida have to do largely with salt marsh species. Periodically, flood water mosquitoes have been a most annoying pest to all residents along the lower Columbia River. In fact, during 1938 the mosquito pest reached acute proportions throughout the city of Portland and some thirty odd clubs demanded that the city and county commissioners take steps to remedy the evil. All forms of agricultural, lumbering, and recreational activities are affected by the flood water mosquito pest in the lower Columbia River valley and by entirely different groups of species elsewhere in the Northwest Region. Salt marsh mosquitoes are responsible for heavy losses to agriculture, fishing, and industrial activities, and especially for retarding the development of resorting areas on the Atlantic and Gulf coasts. The general economic trend toward reducing the number of working hours per day and week provide added time for many lines of recreation which cannot be enjoyed because of the mosquito pest. In certain sections of the country considerable sums are now being spent in attempts to control these pests.

Plan and Progress of Work: Experimental tests are being conducted on new biological, cultural, and chemical phases of control. And, in order that the most vulnerable point of attack be learned, detailed studies are made on the life history of the several species. These studies will determine the flight range, span of life, egg-laying preferences, etc. Investigations of the effect of different types of ditching on marshes of various sorts constitute an important phase of the work since this method of control is closely related to wildlife in the marshes. Of the organic compounds tested, the most promising results were obtained with some of the azo derivatives of phenols as larvicides. Further work with these compounds is therefore warranted.

(b) Sandfly Investigations:

Objective: To develop effective and economical methods of control of sandflies and of protecting man and livestock against them.

The Problem and Significance: Although sandflies are not definitely known to carry diseases, they are of prime importance to man in certain sections of the country, particularly along the southeast seaboard. Investigations under way are headquartered at St. Lucie, Florida. The habits of only a comparatively few species of sandflies are known. These breed in the extensive salt marshes about the coast. Certain species in the area mentioned have retarded development and held down property values. Much of the region in which they occur is famous as a winter resort. A number of bankruptcies of resort hotels are attributable to the presence of sandflies. The development of effective control methods for these insects will also have a direct bearing on the protection of personnel at military and naval bases along the coast. In certain individuals a severe dermatitis is caused by sandfly bites, and there is some indication that they may transmit three-day fever of man. These insects are also a severe annoyer of livestock, sometimes resulting in lowered condition of the animals and in screwworm attack.

Plan and Progress of Work: It is now possible to suggest control measures which will materially reduce the number in certain species. This suggested control consists of draining a marsh or by means of diking to prevent the marsh from becoming flooded by high tides; however, the value of these methods should be further tested, especially with reference to the effect of pumping out diked areas, and ways devised to combat those species breeding in holes in trees and along streams. Preliminary experiments indicate that the clearing of vegetation from certain types of marsh will greatly reduce sandfly breeding. It appears, however, that such a procedure is practical only in small isolated marshes inasmuch as the cost of clearing is expensive. It has been shown that very few sandflies appear to migrate further than 4-1/2 miles from the marsh from which they emerged.

(c) Secretions of Insects and Their Effect on Man and Animals:

Objective: The work on surgical maggots has revealed the medicinal value of the secretions of these organisms and has resulted in the discovery that certain chemicals found in these secretions, such as allantoin, urea, and ammonium bicarbonate, are of great value in healing infected gunshot wounds and other slow-healing lesions. These investigations have indicated that a broader study of the secretions of insects would possibly develop other products of a beneficial nature as well as give a better insight into the problem of how the secretions of harmful species produce their injurious effects, and indicate methods of counteracting such effects. A further inquiry into the way in which these excretory products

stimulate normal cell development will be made as this is fundamental to many problems in human and veterinary medicine and also has a bearing on plant life.

The Problem and Significance: Experimental work with maggot therapy was begun on a small scale in 1930 in cooperation with Dr. Wm. S. Baer, who suggested this treatment as a result of World War experiences. Methods of producing and shipping sterile maggots suitable for use in chronic osteomyelitis cases were developed, and this treatment returned to sound health and productivity hundreds of people who had been invalided for years; however, the cost of using this treatment was excessive, and there was considerable antipathy to the employment of live maggots in human tissues. The Bureau then set about the determination of the reasons maggots produced such beneficial results. At least part of these benefits were found to be derived from the excretions of the larvae as they fed in the diseased tissues. Further studies showed that several chemicals found in the excretions were highly beneficial in suppurating wounds; among these were allantoin, urea, and ammonium bicarbonate. The discovery of the fact that these materials increase the resistance of tissues to the attack of disease and actually stimulate cell multiplication and hence rapid healing has been recognized as an outstanding accomplishment in the field of medicine. The value of urea in the healing of gunshot wounds and many other types of dangerous lesions and slow-healing sores is manifest, when we consider that this material is produced synthetically in great quantities and at a price as low as $0.05 a pound.

Plan and Progress of Work: Several chemicals which occur in the excretions of maggots have been found to be highly beneficial in the treatment of osteomyelitis and other suppurating lesions; however, none of them appears to have the outstanding property of the maggots themselves to heal and restore bone tissue. It appears that workers in this field now have some idea of what products in secretions to look for that can duplicate the cleansing and regeneration of bone, one of the most important functions of the maggots. Studies on the secretions of insects during 1939 have had a far-reaching influence in the field of biology and medicine. These studies have revived an interest in the enzyme urease, which although it has been known for the past 80 years, has been largely neglected in the field of biology. Rapid progress on the practical side of the problem has been made possible by the active cooperation of scores of physicians who have been willing to determine the effects on lesions of various types and report these results to the Bureau for analysis.

(d) Ticks Affecting Man:

Objective: To determine facts upon which to base control methods and to develop such control methods so that they will be practical for use against the several important species of ticks that occur in the United States.

The Problem and Significance: The role that ticks play in transmitting such diseases as tularemia, relapsing fever, and Rocky Mountain spotted fever, makes the study of the biology, habits, and methods of control of these parasites of great economic importance. Ticks are the sole carriers of Rocky Mountain spotted fever of man. Each year some 150 cases of this disease occur in the eastern United States with an average mortality of about 23 per cent. In addition to their disease-carrying propensities, many species of ticks are severely annoying to recreationists and dogs.

Plan and Progress of Work: Investigations on the American dog tick in New England are centered on the island of Martha's Vineyard, Mass. These were begun in the fiscal year 1938 and are being continued with a view to the development of effective control measures. Among the more important results of the work to determine methods of controlling the American dog tick, the following may be mentioned: (1) the more important points in the biology of the tick have been determined; these include the establishment of the length of life without hosts of the several stages, and that the seed ticks and nymphs develop mainly on meadow mice and the adults on dogs and other large animals; (2) an effective dip for destroying ticks on dogs has been developed, but it must be used every 5 days to prevent ticks from engorging; (3) the attempt to eradicate ticks from a given area by the systematic dipping of dogs was continued for the second season without a noticeable reduction in adult ticks; (4) about 100,000 tick parasites were reared and released at certain points where the tick population was high; although a decline was observed in the number of ticks in the areas, attempts to recover the parasites in these areas were unsuccessful; (5) extensive tests were conducted to determine the efficiency against adult ticks when sprayed on vegetation. In these tests about 90 per cent reduction in the abundance of the ticks was apparent after 48 hours. This degree of control is sufficiently high to warrant the use of this method in some cases; (6) cooperative experiments with the Fish and Wildlife Service to determine the possibility of tick eradication by destroying field mice gave the most promising results, but the practicability of this procedure has not yet been determined.

Although information on the life histories, hosts, and distribution of a number of other species that attack man has been and will continue to be gathered, major attention is being given to the American dog tick, as it is one of the most important species, and the funds are not adequate to undertake an intensive study of several species simultaneously.

(e) Clear Lake Gnat Investigations:

Objective: To determine methods of reducing the numbers of gnats, where a particularly troublesome situation exists, to the point where they no longer constitute an economic pest.

The Problem and Significance: The Clear Lake gnat is a species of midge which breeds in enormous numbers in Clear Lake, California, and other similar bodies of water in the Pacific Northwest. Under certain conditions throughout the summer these insects emerge from the lakes in myriads and are attracted to lights in residences, stores, and places of amusement in such numbers that they become a serious economic pest. At times they becloud automobile windshields, making traffic slow and dangerous. In these ways they have detracted from the recreational value of the areas, and have interfered with commercial enterprises. From the health standpoint, it is indicated that people frequently become allergic to the gnats, and in these instances the presence of the insects elicits reactions similar to those caused by hay fever.

Plan and Progress of Work: A field laboratory has been established at Nice, California where investigations are under way on the biology, habits, and distribution of the Clear Lake gnat. Studies are also being made on the possibility of controlling the pest by the utilization of fish or other aquatic predators on the larvae. Various chemicals are also being tested to determine their value for destroying the immature stages of the insects. Considerable improvement has been made in electric light traps for destroying the gnats. An especially designed trap of the double-action type has shown great promise. In fact, two such traps fitted with small motors and operated 75 yards apart took 1,750 pounds of gnats during the season of 1939. A large trap of the same type took 800 pounds in a forty-day period and a maximum nightly catch of 88-1/4 pounds, or approximately 88,000,000 gnats. Much important basic information has been obtained, but much remains to be done as the problem is a complicated one involving the conservation of fish and other natural values.

Project 2. Household Insects.

General: This project provides for investigations of insect pests in dwellings, hotels, apartment buildings, and other living quarters, those annoying householders and those destroying household supplies, drugs, fabrics, and the development of methods for their control.

(a) Insects Affecting Fabrics.

Objective: (1) To devise and develop effective, safe, and economical methods of preventing insect damage to fabrics.

Problem and Significance: Damage done to clothing, carpets, upholstered furniture, and fabrics of all kinds by such insects as clothes moths, carpet beetles, and silverfish causes an annual loss of many millions of dollars to householders, warehousemen, storekeepers, manufacturers, and others. These insects are cosmopolitan, and the losses caused by them fall on every individual. Many of the methods previously used in combating these pests have become outmoded and are no longer adequate to meet the complex problems of

today. New problems relating to insect damage to certain insulating materials, rugs, upholstering, and other furnishings in apartment houses, and raw and finished products in factories are constantly being presented to the Department for solution. The accelerated program of national defense involves the handling and storage of large quantities of uniforms, blankets, and other military supplies. These must be properly protected against fabric pests. Many problems are being presented to the Bureau for solution, as was the case during the last war. Further research work on these special problems is necessary to adequately and effectually meet these emergencies.

Plan and Progress of Work: A few mothproofing solutions have been perfected and applications for patents have been made but a great deal of further research in mothproofing agents is necessary to meet the urgent demand for safe and effective materials which will protect fabrics against moths for long periods of time and under varying conditions. Tests have been conducted in cooperation with manufacturers, warehousemen, and merchants, insofar as funds permit, to determine the feasibility under practical conditions, of control methods as developed in the laboratory. Investigations of serious infestations of houses and apartments with clothes moths and carpet beetles emanating from insulation have shown the desirability of discontinuing the use of animal hair in the insulation of buildings.

(b) Insects Affecting Foods.

Objective: To devise and perfect methods of preventing insect damage to food products.

Problem and Significance: Millions of dollars' worth of food products of all kinds are lost in this country each year as a result of insect depredations. There is an insistent demand on the part of consumers, merchants, and warehousemen for information on means of preventing this loss. Such losses are especially unfortunate in that the products destroyed represent the expenditure of much labor and money in production, transportation, packaging, and distributing these products. Furthermore, the contaminated food products may be deleterious to human health. The development of cheap and effective control measures for the many different types of insects involved has a very definite and vital bearing on the storage of food supplies to meet national emergencies. The Federal government alone, through its various procurement activities, loses large sums each year as a result of the depredations of insects affecting stored foods, and this situation will be further accentuated by the proposed increase in the country's armed forces.

Plan and Progress: To date this project has been conducted with a view to meeting general requests for information. In many instances the facts and information have been too meager to satisfy the demand, and certain specific problems will be attacked as expansion

of work becomes possible. One of the important problems is the development of a practical and safe method to free prepared foods of insects before packaging them and to develop packages that will exclude insects of all types and under varying conditions of storage. Tests should be made to develop better methods of protecting bulk commodities, such as seeds, beans, and peas against insect infestation in warehouses, stores, and homes. Investigations should be made on methods to prevent insect damage to raw materials being held for processing. Many of these tests could be carried on in cooperation with manufacturers, warehousemen, merchants, and house owners.

Project 3. Insects Affecting Animals.

This project provides for investigations on insects injurious to horses, cattle, sheep, goats, swine, and other domestic animals, and the development of methods for their control. These activities are described in the following sections.

(a) Screwworm and Blowfly Investigations.

Objective: (1) To develop more effective and lasting materials for the protection of wounds in livestock against screwworm attack; (2) to discover a larvicide quicker in action and more effective than benzol; (3) to find materials and develop methods of their application for the control of fleece worms; (4) to develop modifications of ranch practices in the overwintering areas of the screwworm and areas adjacent so as to reduce losses there and retard the usual annual northward sweep of this destructive pest.

Problem and Significance: Screwworms and other blowflies cause enormous losses to the livestock industry in the southern states each year. These losses amount to from 5 to 10 million dollars annually. All classes of livestock are attacked and the pest destroys considerable wildlife and occasionally attacks man. These insects constitute one of the principal problems in the economical production of cattle, sheep, and goats in one of the largest range livestock sections of the country. In the Southeast they are also a serious handicap to hog raising, especially when the hogs are pastured. The fact that the screwworm assesses such a heavy tax on the producers of vital necessities such as beef, wool, mohair, and hides, and that the insect is strongly migratory, spreading each year from restricted areas in south Texas and southern Arizona and Florida to some 15 or 20 states to the north, gives this problem a decided Federal aspect.

Plan and Progress: It is planned to continue work now under way to discover a chemical which will protect wounds of various types from infestation or reinfestation by screwworms for a considerable period, also to develop simple and effective methods of application. It is difficult and expensive under range conditions to round up and treat all infested animals daily as is now necessary

with the standard remedies. There is also need for a quick-acting and highly dependable worm killer because the average ranch hand often fails to kill all the worms with benzol, now advocated by the Department, and a few worms left make the wound attractive to flies and reinfestation promptly results and the injured animal often hides and soon succumbs.

This phase of the work has been carried on mainly at Menard, Texas, where a ranch stocked with about 1,000 head of sheep, goats, and cattle, is leased by the Government. Preliminary tests with chemicals, many of which are new synthetic organics, are conducted on screwworms which are reared on an artificial medium developed by that station. The chemicals are then tested on small numbers of Government-owned animals, then on larger numbers in pasture. More than 500 chemicals have been given preliminary tests and several of these have shown decided promise. Three of the better ones have been tested on privately owned ranch animals under practical conditions, and one, diphenylamine, has been recommended to the public and is being favorably received. In the field work of testing these three materials, over 1,700 screwworm cases have been treated and full notes made on the wounds until healed. It is planned to proceed along similar lines with the other promising chemicals and to develop methods of applying these materials so they will give better and more lasting protection to the wounds. Combinations of larvicides and wound protectors are also to receive attention. Studies have been intensified to determine the foci of overwintering flies in southwest Texas, and the localities where the population of screwworm flies build up in the spring to reinfest the rest of Texas and adjoining states on the north. Consideration is being given to the modifications of present ranch practices designed to reduce winter holdover and check northward spread.

(b) Cattle Grub Investigations:

Objective: To develop methods for controlling cattle grubs, especially under range conditions.

Problem and Significance: The larvae of certain flies, commonly known as cattle grubs, not only greatly injure hides, but materially interfere with the effective management of dairy and range cattle. The annual losses from these insects are estimated as high as $50,000,000. This loss is felt by dairymen, raisers of beef cattle, feeders, packers, tanners, leather dealers, and the users of leather goods. There are two species of cattle grubs in the United States and one or the other of these is present in every state. It may thus be said that the loss from this pest touches every resident in the country.

Plan and Progress: Although methods of controlling this pest in dairy herds have been developed, the major loss probably occurs among range cattle and there has been manifest recently an active

interest in grub control on range stock. In fact, the Department is being pressed for advice on the best methods. In cooperation with ranch owners and the Texas Agricultural Experiment Station and Extension Service, studies are being made on the control of cattle grubs in range animals in King, Hemphill, and Baylor counties, Texas. On some of these ranches where experimental control work has been carried on for two seasons, the grub population was observed to be reduced about 84 per cent. Some experiments were undertaken to determine the effect of dipping cattle in a sulphur-cube dip for the control of cattle lice and the killing of cattle grubs. It was found, however, that the dip ordinarily effective in controlling cattle lice was effective in killing only from 20 to 60 per cent of the grubs.

(c) Lice, Mites, and Head Bots Attacking Animals:

Objective: To develop practical methods of control of lice, mites, head bots, and sheep ticks and thus make stock raising more remunerative.

Problem and Significance: In the large livestock-raising areas of the Southwest, sheep and goat lice and the sheep tick are serious problems from the standpoint of wool and meat production. These insects, by damaging the wool and mohair fibers, by irritating and emaciating the animals, and by predisposing the animals to screwworm attack, cause a heavy loss annually. Approximately 85 per cent of the Angora goat industry is centered in western Texas where the several species of lice abound. The nostril fly of sheep and goats is rather widely distributed in the United States and by its irritation and annoyance prevents the animals from grazing properly and consequently keeps them in poor condition. This is an old problem and much controversial data have appeared. Severe damage is reported by many ranchmen which necessitates a complete study of the problem. The cattle lice are a widespread and destructive pest on range cattle, particularly breeding stock. One of the species of cattle lice, the short-nosed ox louse, is not controlled by the usual dips, and losses due to it are apparently increasing. The stockmen are urgently demanding an effective remedy.

Plan and Progress: As a result of these investigations carried on at Sonora, Texas, an effective and inexpensive and nonpoisonous dip has been developed for controlling all kinds of lice on goats. This method has attracted much attention, and in cooperation with the extension agencies in the Southwestern States, its use is being popularized.

Much progress has been made in the study of wetting agents for increasing the efficiency of these sulphur dips. Some of the formulae which in laboratory tests appeared successful did not give satisfactory results when lousy animals were treated, especially in dips in which hard water was used. Combinations of

2 or 3 different wetting agents were found to be superior to any single agent. Twenty such combinations can now be recommended as giving the maximum toxicity and better retention of sulphur on the skin of the animal and in the hair. In cooperative tests with the Texas Extension Service and ranchmen, approximately 7,000 head of cattle have been dipped in a sulphur-cube dip for the control of the blood-sucking, short-nosed ox louse. With only one exception, two dippings gave satisfactory control. The one failure apparently was due to an improper dipping interval. Tests have been initiated to determine the effect of feeding sulphur to infested animals for the control of various species of lice. After five months, the infested animals which received a daily ration of 5 grams pure elemental sulphur for every 100 pounds live weight continued to show louse infestation, contrary to the popular idea that sulphur feeding will rid animals of lice.

(d) Fly Sprays and Repellents:

Objective: To develop a spray that will kill all flies struck and give protection for a reasonable period after application, without injury to the animals treated, and also to perfect a practical method of testing livestock sprays.

Problem and Significance: There is a great demand by livestock owners, especially dairymen, for a fly spray that will accomplish the above objective. The horn fly, stable fly, house fly, and horse flies are serious pests of livestock and man. Their attack results in loss of milk flow, in lowered condition of all classes of livestock, and in contamination of diary products, which lowers their quality and may cause diseases of man and other animals. Many livestock sprays are sold to the public which are ineffective and some that are likely to injure the stock or dairy products. The fly spray business has grown tremendously and at present probably amounts to $25,000,000 annually. There is no satisfactory test for livestock sprays and the development of such a test would do much to standardize these materials and protect the farmers and others. These fly problems are encountered in all sections of the country.

Plan and Progress of Work: A series of tests was made with a number of different types of spraying equipment to determine their relative value for the destruction of dairy flies. A total of 16 new materials has been tested against dairy flies, of which only 4 displayed any toxicity, and none of those exerted a sufficient poisonous effect to warrant further investigation. A total of 88 materials was tested for their poisonous effect on house flies, and only 6 were found which caused greater than 20 per cent mortality in 24 hours. Sixty-four carbon compounds were tested to determine their repellence toward house flies, and only 4 of these showed strong repellent properties. Further work is being undertaken with these materials. Considerable work has been done on determining the test methods for preparing homemade fly sprays. In this project it was determined that probably

the most efficient method that could be undertaken in the home manufacture of the sprays would extract only 75 per cent of the insecticidal material found in pyrethrum flowers; however, even with this comparatively low efficiency, a relatively good spray can be made for approximately 82 cents per gallon. It was also determined that perhaps the best method of preparing home-made fly sprays was to dilute the ordinary commercial 20-to-1 or 30-to-1 pyrethrum concentrate with kerosene and that a good quality spray could be made in this way for approximately 42 cents per gallon.

(e) Ticks Affecting Animals:

Objective: To develop new and effective control measures against important ticks parasitic on livestock and pet animals, such as the Gulf Coast tick, the brown winter tick, the brown dog tick, and the Lone Star tick. These ticks are widely distributed, and some of them are serious handicaps to livestock raising; others are important pests to dogs and in the household. The Bureau is being urged to make recommendations for control, but no sound control procedure has yet been developed.

Problem and Significance: Gulf Coast tick injury is one of the major predisposing causes to screwworm infestation in the Southeast, Because of its habit of congregating and feeding in groups, it is greatly irritating and injurious to stock. The brown dog tick has been spreading to new localities and has become a particularly serious pest in many areas. Recent investigations have disclosed that infestations of the winter horse tick are more widespread and more injurious than it was thought when these investigations were first undertaken. Apparently, the arsenical dip recommendations set forth for the control of ticks on horses are not applicable to the winter horse tick because, first, ranchmen hesitate to dip their horses in the winter when the tick is most abundant, and second, very little or no protection from reinfestation has been obtained by ranchmen that have used the treatment. Preliminary field and laboratory tests conducted on the control of this pest have given some encouraging results. In addition to their importance as parasites of animals and as household pests, there is evidence that certain diseases are carried by them, such as tularaemia, anaplasmosis, and canine piroplasmosis.

Plan and Progress of Work: Studies of the biologies of the more important species of ticks are to be continued, and data on distribution and hosts of ticks in the United States gathered from various sources will be assembled for publication.

A number of organic compounds has been tested against the winter tick and Gulf Coast tick. Diphenylamine, p-nitrophenatole, and p-nitroanisole were shown to have tickicidal properties.

Castor oil alone and in combination with diphenylamine gave encouraging results against the brown winter tick. Preliminary experiments with range burning indicated that although many ticks in all stages were destroyed, complete kills do not result under any condition of grass and do have the added disadvantage of destroying wildlife food and protective shelter. An outstanding accomplishment during the past year was the discovery of certain materials that apparently retain their tickicidal action for a month, and the determination that bayol is reasonably cheap and effective material for the destruction of the brown winter tick.

(f) Horn fly Investigations:

Objective: To gather information on the biology and habits of the horn fly and based thereon, to develop effective and economical control measures against them.

Problem and Significance: Horn flies have long been a serious pest of dairy, feeder, and range cattle, as well as other domestic livestock. In addition to their annoyance to animals causing a reduction in milk flow and loss of flesh, these insects, by their feeding habits cause abrasions of the skin and in this way predispose animals to the attacks of screwworms. In regions where screwworms are a major pest, horn flies are one of the most important factors inciting the attacks of these parasites. Horn flies are indicated to be the principal carrier of a nematode parasite in the skin of cattle. These parasites also cause lesions which induce screwworm attack and which detract from the value of the hide for leather. This pest is found throughout the country and no satisfactory control is known for it under range conditions.

Plan and Progress: Completion of improvements on the cattle fly trap developed during the previous year has now placed in the hands of dairymen and, to a certain extent, ranchmen, a good and relatively cheap method of controlling horn flies and, in a limited degree, stable flies. A public service patent on this trap (No. 2,181,595) was granted but further experiments with the trap are contemplated to determine if it is possible to increase its efficiency, and adapt it to other types of livestock management. Although there remains considerable work to be done in the biology of the horn fly, the investigations have been complete enough to permit the publication of a leaflet and more technical bulletin on this subject. Studies on the medication of cattle for the control of horn flies were continued. Of 29 chemicals so far tested, rotenone is by far the most effective.

As a result of these investigations it has been shown that the breeding of horn flies in the dung of cattle can be prevented by feeding the animals such chemicals as phenothiazine and rotenone. This method has not proved to be practical on account of cost and difficulty of administering proper dosages. Some further work in this field will be undertaken, however. In connection with

the fly spray project, determination will be made of the efficacy of killing sprays, their frequency of application, and cost, to bring about satisfactory control of the horn fly.

(g) Dog Fly Investigation:

Objective: To determine the breeding places of the dog fly along the coast, especially along the western coast of Florida, and to develop control measures which may be used in combating this pest.

Problem and Significance: The dog fly, or stable fly, is a blood-sucking species which is seriously annoying to all kinds of warm-blooded animals, including man. Heavy losses are inflicted on dairy and grain farmers and on feeders of beef cattle nearly every year. Along the Gulf Coast, especially in western Florida, these flies appear in myriads nearly every fall and not only attack cattle, horses, and sheep, but bite people so severely as to drive many away from the beaches and thus greatly interfere with the prosperity and comfort of the adjoining communities. Very little is known where such large numbers of flies might be breeding. This information is needed so that control measures can be properly developed.

Plan and Progress: Investigations on this problem have been under way for one year at a new laboratory located at Panama City, Florida. Methods for rearing dog flies in the laboratory have been developed and extensive surveys of the coast, where the insect is most troublesome, have been made. Methods of determining the abundance of flies at different times of year and under varying climatic and tide conditions have received attention. The use of electric fly traps shows considerable promise for this purpose. Flies have been found to breed in windrows of certain sea plants on the beaches, but the numbers found in such materials do not seem sufficient to account for the outbreaks. A considerable population is affected by this pest, and no other agency is undertaking work on it though many individuals have expressed a willingness to cooperate as soon as some tangible plan of attack has been found.

(t) INSECT-PEST SURVEY AND IDENTIFICATION

Appropriation Act, 1941........................$154,790
Budget Estimate, 1942........................ 154,790

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
1. Insect pest survey.........	$17,986	$19,559	$19,559
2. Identification and classification of insects........	135,229	135,231	135,231
Unobligated balance...........	1,575	- -	- -
Total appropriation......	154,790	154,790	154,790

WORK UNDER THIS APPROPRIATION

General. The research carried on under this item is essential to the various activities of the Bureau and involves identification of specimens and securing and recording of facts regarding the distribution and abundance of economic insect pests. These projects are discussed in detail, as follows:

Project 1. Insect Pest Survey:

Objective: To collect by cooperative reporting from the Bureau's personnel and State entomological agencies detailed information on the occurrence, distribution, and relative abundance of insect pests throughout the United States, and to study these data from month to month and year to year with relation to the several factors that influence abundance.

The Problem and Its Significance: The Survey plans to eventually have very complete distributional information on all North American insect pests, similar information on insects occurring in other parts of the world, and complete lists of the insects affecting any specific plant either in this country or abroad.

Plan and Progress of Work: Once a month the Survey receives reports from its 163 collaborators outside the Bureau, as well as from numerous field stations of the Bureau. During the year the Survey added to the permanent files on the distribution and abundance of insects 25,100 notes on domestic insects and 11,500 notes on foreign insects, bringing the total now available for consultation to 315,250. The work of the year added 800 species of insects to the existing record

of approximately 20,000 species of American insect pests and the foreign pest file now contains over 22,000 species of insects. To the host plant file there were added during the year 25 new genera and 165 new species, bringing the totals to date to 1,125 genera and 2,600 species. During the year a volume of the Insect Pest Survey Bulletin was completed and a new volume started. The complete volume consisted of 10 numbers and was augmented by Supplements on Alfalfa Weevil Spread in 1938, Alfalfa Weevil Survey Fall of 1937, Relative Abundance of the European Corn Borer in 1938, Distribution and Colonization of European Corn Borer Parasites in 1938, The Field Status of Parasites of the European Corn Borer in the Fall of 1937, Grasshoppers--Species and Distribution in the 1937 Outbreak, Hessian Fly Survey at Harvest Time 1938, June Beetles--Population and Host Preferences in Southern Wisconsin in 1935, 1936, and 1937, and Notes on Tobacco Insects in 1937.

Project 2. Identification and Classification of Insects;

Objective: The identification of insects and related forms submitted by the various Divisions of the Bureau of Entomology and Plant Quarantine, by other branches of the Federal government, by state agricultural colleges and experiment stations, by other public agencies, also by individuals throughout the country and cooperative workers and institutions in foreign countries.

The Problem and Its Significance: There are many hundreds of thousands of different kinds of insects, but a large proportion of them are still unnamed and undescribed and their relationships undetermined. Many resemble each other so closely or exhibit such wide variation that accurate identifications can be made only by experts who have a particular aptitude for such work and are highly specialized within comparatively narrow limits. Exact identifications are essential to the proper conduct of research and control activities on insects. Only when such identifications have been definitely established can effective control and eradication measures be developed and applied.

Plan and Progress of Work: Insect material received for identification is sorted in accordance with the group assignments of the specialists, of whom there are 27. As far as possible with the limited preparatorial staff, the material is given special preparation in order to put it into satisfactory condition for study and is then referred to the proper specialists. The larger lots may contain items for reference to all, or nearly all, of them. Identifications are made by comparison with authentically named material in the reference collections and by review of the pertinent existing literature, and are reported to the central office of the Division. Here the determinations for the various lots are assembled and the final reports prepared, after which these are transmitted to the agencies or individuals that forwarded the material. Because most of the existing kinds of insects are still unknown and many groups within all the recognized orders are poorly classified, identification of more than half of the material received involves critical and often extensive study with the object of ascertaining the relatively stable characters in the

group involved, the extent of variability and the basis on which different kinds of insects belonging in that group may be distinguished from one another. Research to determine the correct scientific nomenclature, often representing intricate problems, is also involved in such investigations.

The service work consists principally of making identifications, the number of which has ranged from 60,117 to 77,856 annually during the fiscal years 1937 to 1940. It involves also giving assistance to other entomologists on a large variety of problems in insect classification and nomenclature and the review and criticism of from 80 to 100 manuscripts annually that have been prepared in other Divisions of the Bureau. It is continuing in nature. Associated with this service work is also the necessity for maintaining and constantly improving the extensive and essential reference collections.

In the limited time available for research in classification, each specialist conducts studies on the classification of certain insect groups contained in his assignments and prepares the results of such studies for publication. The number of papers completed and submitted for publication annually has ranged from 32 to 52 during the past four fiscal years. Many of these are short, covering only 6 to 50 manuscript pages, but some are comprehensive monographic treatments, comprising from 200 to 500 manuscript pages or even more.

(u) FOREIGN PARASITES

Appropriation Act, 1941.............	$38,000
Budget Estimate, 1942..............	38,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Foreign parasite introduction	$37,880	$38,000	$38,000
Unobligated balance...............	120	- -	- -
Total appropriation..........	38,000	38,000	38,000

CHANGE IN LANGUAGE

The estimates include proposed changes in the language of this item as follows (new language underscored):

For administrative expenses in connection with the introduction of natural enemies of injurious insects and related pests and for the exchange with other countries of useful and beneficial

insects and other arthropods, $38,000; and not to exceed $1,100 of the funds appropriated to the Bureau of Entomology and Plant Quarantine for the fiscal year 1940 may be used to reimburse employees assigned to carry out investigations in Europe for expenses incurred in bringing their families to the United States in compliance with official instructions directing them to return with their families to the United States.

The purpose of this new language is to provide authority for reimbursing employees of the Bureau of Entomology and Plant Quarantine assigned to investigational work in Europe for expenses incurred in bringing their families to the United States when they were ordered to return to this country at the earliest practicable date on account of war conditions in Europe. These instructions were necessarily given on short notice and required the employees affected to incur unanticipated expenses in connection with the transfer of their families. It was necessary for them to discontinue arrangements they had made and to pay transportation costs in excess of those which would normally have been incurred had there been opportunities to make arrangements under usual conditions. The three employees who were concerned of course had their own expenses back to the United States paid by the Government, but in the absence of specific authority the Department is unable to reimburse them for the cost of bringing their families back to the United States, and in fairness to them it is believed that the unusual circumstances should be recognized by extending the specific authority requested for the payment of these extraordinary costs.

WORK UNDER THIS APPROPRIATION

General. This appropriation provides for administrative and operating expenses in connection with the introduction of natural enemies of injurious insects and related pests and for the exchange with other countries of useful and beneficial insects.

Objective. To collect abroad and establish in the United States parasites for the purpose of attacking insect pests now established in the United States.

The Problem and Its Significance: The value of natural enemies as aids in controlling injurious insect pests has been thoroughly demonstrated by work done over a period of many years. The use of these parasites is a definite part of investigations to develop means for the control of injurious insects, particularly those which are not native to the section where they cause damage. Many of the major insect pests of the United States were introduced with the early development of agriculture and, with a few exceptions, their natural enemies did not accompany introductions. Therefore, studies of their natural enemies and their native habitat and the collection, importation, and establishment of those parasites is a significant part of the whole program of insect control.

Since 1890 a total of nearly 500 species of beneficial insects have been imported into the United States from many parts of the world and 85 have become established. Several of these have given complete control of serious crop pests and others have brought about a marked reduction in crop injury.

Plan and Progress of Work: Work under this appropriation necessarily involves close cooperation with entomologists and other agricultural officials in foreign countries. In some cases, arrangements are made for the exchange of beneficial insects.

The collection of parasites in foreign countries requires the services of specially trained personnel and the maintenance abroad of laboratories with appropriate facilities. At the present time, there are two such laboratories: one in Japan and the other in South America. It has been necessary, on account of the war conditions, to close the Laboratory which was previously maintained in Europe. The work in Japan is conducted from Yokohama, and in South America from Montevideo.

The more important problems now being investigated by the Yokohama station are the Oriental fruit moth and the Comstock mealybug. The latter is becoming a serious pest of apple in the eastern United States but in Japan it is apparently effectively controlled by its parasites. In South America special attention is being given to the search for natural enemies of the white-fringed beetle, the pink bollworm and stainers of cotton, the sugarcane moth borer, etc.

It is also necessary to provide in the United States a parasite receiving station at which parasite material may be received under the most favorable conditions and reared and made available for colonization in the United States. This station, which is located at Hoboken, New Jersey, also holds shipments of natural enemies under quarantine conditions to assure the absence of injurious insects before their release for colonization.

The insects for which natural enemies may be sought attack a wide variety of crops. The expenses connected with the importation of parasites, other than those that are recurring of an administrative nature, are provided for from an appropriation made for studies on the particular pest.

(v) CONTROL INVESTIGATIONS

Appropriation Act, 1941..............$72,518
Budget Estimate, 1942................ 72,518

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Control investigations........	$67,368	$72,518	$72,518
Unobligated balance...........	150	---	---
Total appropriation....	67,518	72,518	72,518

CHANGE IN LANGUAGE

The estimates include a proposed change in the language of this item as follows (language to be deleted is enclosed in brackets):

> For developing equipment or apparatus to aid in enforcing plant quarantines, eradication and control of plant pests, determining methods of disinfecting plants and plant products to eliminate injurious pests, determining the toxicity of insecticides and related phases of insect-pest control, $72,518 [of which not less than $10,000 shall be used for methyl bromide investigations].

Current and proposed expenditures for investigations on methyl bromide exceed the amount specified in this item, and the inclusion of this langauge necessitates the setting up of two separate accounts under the item. This requires additional work for those engaged in the investigations as well as for those responsible for directing them and also entails additional work in the administrative office of the Bureau and in the Department because funds "ear-marked" must be separately accounted for.

The operations necessary because of the language not only involve more work but also fail to give a complete statement of the amount expended under this item for investigations on methyl bromide. The Bureau recognizes and appreciates the importance of this comparatively new fumigant, which is adapted to a wide variety of uses and is particularly valuable in treating plants or plant products, the movement of which may be restricted by plant quarantines. Appreciation of the importance of studies on this fumigant is recognized and the plan of work necessitates the allocation and expenditure of approximately $16,500 for investigations on methyl bromide, which exceeds the amount indicated in the language recommended for elimination.

WORK UNDER THIS APPROPRIATION

General. This appropriation provides for investigations to develop new materials which may be useful for the control of insect pests; for research concerned with the commercial application of methods developed for the sterilization or disinfection of plants or plant products; for the coordination and standardization of methods of disinfection of articles or products the movement of which is regulated by various plant quarantines.

Objective, Problem, and Significance: These studies have an intimate relation to much of the research, control and quarantine enforcement work of the Bureau and may cut across crop and divisional lines. In such cases the work is cooperative and closely coordinated with that done by other units. These activities include technical studies to discover or develop insecticides and to obtain new and needed information on the action of insecticides, repellents, and attractants. An important phase of the work is testing new materials that may be developed as the result of chemical studies to determine their toxicity under laboratory conditions on certain standard test insects and other animals and on plants. This testing of materials goes hand in hand with investigations on the chemistry of insecticides and forms the basis for suggestions for new materials or methods that may be useful against particular crop pests. Those which promise to be of value are given further testing at field laboratories concerned with the control of insects for which they may be applicable. The basic information secured is applicable to many other lines of work on insect control. The activities concerned with sterilization or disinfection of quarantined articles include investigations to develop methods, by fumigation, the use of heat and other means, which will permit freer movement of the regulated articles without endangering the spread of pests.

Plan and Progress of Work: Investigations to determine the application, under varying conditions, of gaseous insecticides in the destruction of insects of economic importance are concerned primarily with methods of commercially applying fumigants for the treatment of products covered by quarantine regulations. These studies aim to develop treatments by fumigation which will make it possible to treat products, the movement of which is now prohibited or restricted by quarantines so they can be imported or moved interstate without accompanying risk of spreading infestations of insects which are the subject of quarantine.

Certain insect pests which may occur in many of the products regulated by quarantine can be killed by heat or by exposure to low temperatures, and these methods of sterilizing plants and plant products are used in connection with certain Federal quarantines. The commercial application of these methods requires constant technical supervision. An important part of the work carried on under the project consists in furnishing this type of service to the unit responsible for the enforcement of the quarantine. Certain pests not regulated by quarantine may be controlled by heat or by refrigeration. Experiments to determine

the effect of high and low temperatures on insects and especially those forms which may be moved in connection with commercial shipments are carried on in cooperation with other divisions of the Bureau.

New insecticides frequently require the development of new methods for applying them. Studies on the development of machinery and equipment for applying insecticides are a part of the activities which come under this project. At present attention is being given to modifying present equipment and developing new equipment for applying insecticides in control operations against certain major pests such as the gypsy moth. These and related studies are carried on in cooperation with other divisions of the Bureau.

An important phase of the work under this project consists of testing new materials supposed to have insecticidal properties to determine their effect on insects. New materials developed by the chemists are tested under laboratory conditions on various types of insects and other animals and on plants as a preliminary determination of the insecticcidal value of the compounds. The materials tested include not only those synthesized by chemists but also preparations of various plants thought to contain compounds of insecticidal value. Ten or fifteen kinds of insects which can be reared in large numbers throughout the year are used in these tests. In addition to testing compounds developed by the chemists, these laboratory tests are intimately associated with the development of strains or varieties of plants which are the source of insecticidal compounds. The breeding and selection work of the Bureau of Plant Industry, in developing strains or varieties of plants such as Cracca virginiana, a native plant known as devil's shoestring, and pyrethrum in an endeavor to obtain strains with a higher insecticidal content, is dependent on these laboratory tests on insects to determine the relative insecticide content of the individual plants. The work begun in previous years along this line has been continued.

A thorough knowledge of the normal physiology of insects is a necessary basis for studies to determine the effect that various kinds of poisons may have on the insect. Physiological studies and investigations on insects are a part of the activities carried on under the project and involve studies to determine the relation of insects to external and internal environmental factors. These serve as a basis for determining the lethal action under abnormal conditions such as temperatures, poisons, etc.

Studies to determine the toxic effect of insecticides on insects include a group of related problems considered under this project. The object of studies of this nature is to determine the effect on insects of various compounds and to ascertain the lethal dosage of insecticides under varying conditions of temperature and humidity.

Tobacco has long been recognized as one of the standard insecticides. Despite a curtailment in the chemical phases of the investigation, necessitated by reduced appropriations, studies are continuing to determine the possibility of using various forms of insecticides made from tobacco as stomach poisons as well as contact poisons. These activities

include not only studies on tobacco extracts themselves, but also the possibility of mixing them in a more effective manner with other materials which would serve as carriers.

(w) INSECTICIDE AND FUNGICIDE INVESTIGATIONS

Appropriation Act, 1941	$125,000
Budget Estimate, 1942	130,000
Increase	5,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Increase
Chemical investigations on insecticides	$134,855	$125,000	$130,000	+ $5,000 (1)
Unobligated balance	129	- - -	- - -	- - -
Total appropriation	134,984	125,000	130,000	+ 5,000

INCREASE

(1) An increase of $5,000 is requested to provide for services and other facilities in connection with the maintenance of the laboratory at Beltsville occupied by the chemists engaged in insecticide investigations.

The Problem and Its Significance: Since the completion of the South Building of the Department of Agriculture the chemists engaged in investigation of insecticides have been housed in laboratories located in that building. Under this arrangement these investigations have received the benefit of common facilities such as heat, light, char service, watch service, water and over-all maintenance which have been supplied by the Public Buildings Administration using appropriations made to that agency by Congress. Because of increasing demands for space in Washington, it has recently been necessary to transfer this activity to Beltsville. It has not been necessary for the Department to solicit appropriations for the furnishing of these common facilities and, in occupying quarters outside of the District of Columbia, it has been the practice to pay necessary operating and maintenance expenses from the applicable appropriations of the agencies occupying the premises.

As no provision could be made for the payment of the additional charges necessitated by this transfer it has been necessary to terminate the appointments of two full-time chemists in order to make sufficient funds available to pay the expenses for the current fiscal year.

This reduction in personnel and curtailment of work comes at an especially unfortunate time. There is urgent need to continue, if not expand, the investigations aimed to develop new insecticides to combat

insect pests. Some of the important insecticides which leave less objectionable residues on market products that have been developed recently as a result of investigations of the Bureau, now widely used, are derived from materials not produced within the United States. War conditions may affect the importation of these materials, thus very seriously interfering with the control of insect pests and also bring into even greater prominence the problem of insecticidal residues. It is important that insecticides that can be derived from materials available in the United States be developed so they can be used in place of materials now imported. To provide funds for facilities and maintenance at the Beltsville laboratory will result in continued curtailment of the work unless additional funds are provided.

Financial Requirements: The increase of \$5,000 to provide for a wide variety of general expenses includes heating, air conditioning, supplying hot and cold water, steam, air pressure, vacuum, gas, electricity, janitor service and telephone service. A force of 20 chemists will be housed at the Beltsville laboratory and large amounts of gas and electricity will be consumed in operating numerous burners, muffle furnaces, distillation apparatus, pumps, grinding machinery and other things that are needed to carry out the investigations. Without experience it is impossible to indicate accurately how the expenses will be divided among the various items. The best information now available indicates that \$2,700 will be required for heat, light, and power; that the cost of water and sewage will be approximately \$400; and that telephone charges will be \$150. Estimated costs of various other items which will be required in the operation of the laboratory vary from \$75 to \$800 per year. These costs would be of a continuing nature.

WORK UNDER THIS APPROPRIATION

General. This appropriation provides for investigations to develop better and cheaper materials for destroying injurious insects and fungi; for the development of methods of manufacturing these materials; for investigation of chemical and physical properties of such materials; and for the study of chemical problems relating to composition, action, and application of insecticides and fungicides.

Objective: To improve the chemical materials, equipment, and methods employed in controlling obnoxious insects in order to enlarge the return to the farmer by increasing the quality of the farm products produced or lessening the cost of producing them.

The Problem: The use of insecticides is one of the most effective ways of controlling many insects which affect or injure man, his crops, and belongings. For no insect pest can we say the method of control now recommended cannot be improved. For many of the insects injurious to crops the insecticides now available are not fully effective and for many others, available materials are definitely objectionable because of the residue which remains on market products. For many insects the

insecticides now available are effective only by repeated use of such agents, which entails large cost and results in accumulation on the treated crop of quantities of residues deemed dangerous by health authorities. The use of the best available methods thus requires repeated effort in time, labor, and additional cost to remove them. Continuous research work is needed to find new or more powerful insecticides that are less dangerous to the plants and animals to which they are applied and to the man and animals that eat the treated food crops.

Significance: It has been estimated that there are approximately 10,000 species of insects in this country that are pests of importance in various localities and seasons. About one-tenth of all growing crops are destroyed annually; a vast amount of damage is done to stored grains, flour, dried fruits, nuts, tobacco, wool, hair, and other products. Wood in buildings is destroyed and weakened by termites. Man and domestic animals are annoyed by many kinds of insects and many kinds of gnats, ticks, etc. carry diseases which cause extensive losses. The estimated damage by insects has been put at over one and one-half billion dollars annually. Much of this loss is preventable if remedies are applied but the toll is so extensive that every effort should be made to discover more effective control measures, of which chemical control is certainly one of the most important. The more obvious materials have been tried. The problem is complex and requires extensive research by chemists in many new fields and close cooperation with those trained in entomology. Not only should new materials be developed, but ways of mixing them with various carriers, diluents, spreaders and adhesives involving numerous questions which can be solved only by chemists.

Plan and Progress of Work: The work now under way is planned and directed with a view to improving present insecticides and developing new ones. In the case of the established arsenical insecticides such as lead arsenate, calcium arsenate and Paris green, their chemical and physical natures are studied, methods of analysis devised, spray residue from their use investigated, and means of removal developed, and accessory materials designed to improve their application to foliage and their retention thereon. New organic insecticides, which are generally considered to offer much less hazard to the public health, are continually sought among naturally occurring plant and animal materials, and a systematic search for potent synthetic organic compounds is continually carried on. Definite progress has been made, as witnessed by the development of suitable washing procedures for removing arsenical spray residues from apples; the introduction of fluorine-containing insecticides, notably cryolite; the demonstration of the insecticidal efficacy of the rotenone-bearing plants, derris and cube, with a subsequent rapid adoption of them as very important means of control; and the development of phenothiazine, xanthone, and numerous other synthetic organic compounds as possible substitutes for the arsenicals. Detailed plans of the work are discussed in the following paragraphs:

Some of the most useful insecticides--for example, pyrethrum, nicotine, derris, and cube--are natural products of plant life. It

is believed that there are many other plants which have insecticidal properties of value. The activities under this work project aim to discover such plants, study the constituents to which the toxicity is due, and to develop useful insecticidal preparations of known merit. Special attention is being given to derris, cube, and pyrethrum. An effort is being made to find ways of preventing the decomposition of the effective insecticidal constituents of extracts of derris and cube and to study the relationship between the active principles, such as rotenone and deguelin. Study is being made of certain native plants to determine those which contain considerable quantities of insecticidally active ingredients.

American farmers are today dependent upon pyrethrum, derris, and cube for the control of many insects such as many kinds of flies attacking dairy cattle and horses, lice, ticks, and other external parasites of poultry, cattle, and sheep; and plant pests such as the pea aphid, pea weevil, Mexican bean beetle, cabbage worms, European corn borer and many others, which have been estimated to cause damage amounting to several million dollars annually. Pyrethrum flowers are used in this country for the control of flies, mosquitoes, cockroaches and other household pests, also as the principal ingredient of cattle sprays; and for combating the celery leaf tier in Florida, cabbage worms on Long Island, and numerous other insects. The quantity so used amounts to about 15 to 20 million pounds annually, and the annual retail value of sprays and powders containing pyrethrum is not less than $40,000,000. None are produced in this country, the larger part coming from Japan with Kenya Colony in South Africa assuming increasing importance. Derris has proven itself very valuable in control of all external parasites of animals, such as fleas, lice, and ticks; also the pea aphid, pea weevil, Mexican bean beetle, and cabbage worms, and is imported from the British and Dutch East Indies in quantities amounting to about one million pounds per year. It cannot be grown in continental United States. Cube is effective against the same insects as are controlled by derris. It comes only from South America, and is used to the extent of about two million pounds annually. The retail value of sprays and dusts containing cube or derris or the rotenone extracted from them is about $5,000,000.

Investigations are under way to develop organic compounds which have insecticidal properties but leave residues relatively non-injurious to warm-blooded animals or man. Hundreds of organic compounds have been obtained or synthesized. Special attention is being given to methods of using phenothiazine, diphenylamine, and a few other compounds that have shown particular promise.

Investigations of various chemical problems connected with the removal of spray residues are closely coordinated with investigations carried on in other units of the Bureau and in the Bureau of Plant Industry. Continued effort is being made to develop better chemical methods for removing objectionable residues. Analyses are made to determine the amounts of residues resulting from various spray formulae. Work includes not only studies on apples but also studies

on other food crops, such as peaches, grapes, cherries, berries, and cabbage. In addition to determining the residues of lead, arsenic, and fluorine which result from the use of insecticides such as the arsenicals and cryolite, attention is also being given to the determination of residues from the use of organic compounds such as derris, nicotine, and phenothiazine.

Studies on inorganic insecticides are directed to the improvement of common inorganic insecticides and the development of possible new combinations which have desirable characteristics. By far the larger quantity of insecticides used are of inorganic origin. Some of these are effective against the insect but are more or less injurious to the foliage. The behavior of these materials is sometimes variable and insecticidal properties may be improved and modification made in their manufacture. Other materials may be developed by improving their physical properties. Calcium arsenate and sodium arsenite are being intensively studied to determine the basic facts governing their usefulness as insecticides.

Chemical investigations on fumigants aim to develop new methods of using well-known chemical compounds for fumigation of growing material or stored products, to increase their efficiency, and to reduce the cost of operation. It is also aimed to find new compounds which may be used as fumigants and to determine the correlation between their chemical constitution and toxicity to various insect pests. These activities are closely correlated with those of other units in the Bureau. Special attention is being given to fumigants that may be effectively used for the control of the resistant form of the California red scale of citrus and to the chemical phases of work on fumigants for use in mills and milling machinery.

The application of insecticides frequently requires the use of other substances not primarily active. Studies are under way to determine the composition, characteristics, and uses of a large class of materials which in themselves have no insecticidal properties but are used in conjunction with insecticides to improve their application. Materials of this class include the inert powders added to improve the distribution of insecticidal dusts and the substances used to increase the wetting, spreading, penetrating, and adhesive properties of sprays. As a part of this activity a study is being made of stabilizers to protect various materials from the effect that weather conditions may have on their toxicity. A wide variety of products is studied in connection with these activities.

In carrying on both the investigational and control activities of the Bureau there is need to have many materials analyzed so their constituents will be known. The chemical activities of this type are primarily of a service nature but include the analyzing of samples of miscellaneous insecticidal materials to determine whether they meet specifications and the determination of the constituents of materials tested by various laboratories of the Bureau, and hence usually have a definite bearing on research.

(x) TRANSIT INSPECTION

Appropriation Act, 1941..........$44,059
Budget Estimate, 1942............ 44,059

PROJECT STATEMENT

Project	1940	1941 (Estimated)	1942 (Estimated)
Transit inspection......	$43,957	$44,059	$44,059
Unobligated balance.....	102	- -	- -
Total appropriation.	44,059	44,059	44,059

WORK UNDER THIS APPROPRIATION

Objective: The inspection of shipments in transit by common carriers at principal transfer points in order to augment the quarantine enforcement activity of the insect and plant disease control and eradication projects and assist them in the interception of shipments of quarantined material moving interstate in violation of Federal domestic plant quarantines and assist the States in the enforcement of State plant quarantines by reporting shipments which are observed during the course of regular inspection activities and found to be moving interstate in violation of such quarantines.

The Problem and Its Significance: (1) Through ignorance of regulations, inadvertance or other reasons, shipments may be accepted for interstate movement which may carry injurious insects or plant diseases from infested or infected areas to other areas not yet affected. Such shipments, which may originate at points throughout large areas are routed through transfer points or gateways where inspection of large quantities of material moving interstate is practicable. The interception and inspection or return of such shipments is instrumental in preventing the spread of such insects and plant disease and in directing the attention of the public to the necessity for caution in the shipment of articles which might harbor them. During the fiscal year 1939, 3,719 violations of 8 of the 9 domestic plant quarantines were intercepted, 2,233 of these were of the Japanese beetle quarantine and 1,119 of the gypsy moth quarantine. In addition, over 550 violations of State quarantines were reported to State authorities. This activity involved the inspection of more than 1,160,000 shipments in transit and the examination of nearly one million way bills.

(2) Additional protection to the agricultural resources of the country has been afforded by the enactment of the white-fringed beetle quarantine, effective January 15, 1939, which will result in an expansion of the activities of the project to cover additional gateways through which material moves from the newly quarantined area.

Plan of Work: The extensive areas under regulation by domestic plant quarantines, which involve the entire United States, require the conduct of inspection at many of the principal gateways through which material moves by mail, express, freight, and other common carriers, especially in the northeastern, middle western and southern States. The project is therefore divided into three regions with from 5 to 8 stations in each region, under the direction of a regional leader. Valuable aid in conducting the work is obtained from employees of the Post Office Department and other common carriers who assist inspectors by watching for shipments of quarantined materials and reporting or holding them for inspecting. In addition, the Japanese beetle, Gypsy Moth and other projects of the Bureau assign inspectors to assist especially during rush periods, and the States assist by the assignment of inspectors at many terminals during the spring and fall shipping seasons. The State of Florida maintains a year-round transit inspection service at Jacksonville, Florida, and all quarantine inspectors in California cooperate by reporting and taking action in regard to violation of Federal domestic plant quarantines intercepted by them during their regular inspection of material entering the State.

Some of the stations may be effectively operated by one inspector, but the more important terminals require 2 to 5 men for effective operation. Additional inspectors are needed during the periods of heavy shipment of nursery stock in the fall and spring to augment the regular staffs and operate other stations of seasonal importance.

(y) FOREIGN PLANT QUARANTINES

Appropriation Act, 1941	$680,000
Budget Estimate, 1942	700,000
Increase	20,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Increase
1. Import and permit service for issuance of permits for the importation of plants and plant products to comply with plant quarantines	$58,236	$58,348	$58,348	---
2. Inspection at ports of entry of plants and plant products regulated by plant quarantines	621,317	621,652	641,652	+$20,000 (1)
Unobligated balance	447	- - -	- - -	- - -
Total appropriation	680,000	680,000	700,000	+20,000

INCREASE

(1) An increase of $20,000 is requested for operation of the new plant receiving and inspection station at Hoboken, New Jersey, (Chief Operating Engineer $2600, 4 Assistant Engineers $8000, 1 Laborer $1200, Supplies and Materials $5200, and heat, light and power $3000.

Objective: To provide for the maintenance and operation of the Plant Inspection House and Parasite Receiving Station which has just been completed.

The Problem: The completion of the new Plant Quarantine Inspection station at Hoboken, N. J., and the transfer of activities to this station which had heretofore been conducted in Washington, D. C., make it necessary to provide (1) adequate inspection at this new plant, and (2) for the maintenance and operation of the building and the extensive mechanical equipment. The inspection force needed is partially provided by the transfer of inspectors from Washington to Hoboken, although it has not been possible to transfer all the force associated with the work in Washington to Hoboken. This is due to the fact that it was necessary to retain a portion of the personnel in Washington, D. C., for inspection of material imported by the Department and provide for the enforcement of regulations governing plants and plant products moving from the District of Columbia in accordance with the Act of 1912, which places on the Department the responsibility of plant quarantine work in the District of Columbia similar to that performed in the states by the several state officials. The maintenance of the inadequate quarters which were available in the District was provided without direct charge to the appropriations of the

Bureau. Heat, light, power, and other facilities were supplied as a part of the over all cost of Governmental buildings. The inadequate technical and mechanical facilities available in the District did not require employment from appropriations available to the Bureau of technicians and mechanics to operate the equipment including furnaces to supply heat, nor was the char and watch service provided by charges to this appropriation. To provide for the operation of the equipment and char and watch service for the building, it is necessary that additional assistance be employed for these tasks. Employment of this additional personnel must be in accordance with established practices and procedures and standards of the trade. This necessitates employing sufficient engineers and watch service to be continuously available throughout a 24-hour day. The building was completed and accepted the latter part of June and was put into service on July 1, 1940. No provision had been made for these increased operating expenses in the appropriations made to the Bureau.

Engineers and labor are needed to provide for the operation of the heating plant, sterilization equipment, fumigation tanks, air conditioning and refrigerating equipment and other mechanical equipment as well as for the upkeep and repair of the building.

An additional factor involved in the operation of the inspection station at Hoboken is concerned with provision of necessary labor. Since there was but one customs broker in Washington, it was possible to arrange with him to station skilled laborers at the Washington Inspection House to work under the control and supervision of the Division for the purpose of handling plant material. The many customs brokers with whom it will be necessary to deal in Hoboken will make this arrangement impossible of application there. Moreover, there would be serious question as to the advisability of attempting to make such an arrangement because (1) the occasional employment of laborers by the several brokers will result in a constant flow of questionable laborers with a decrease in efficiency because of lack of experience, and (2) under customs regulations bonded material must be safeguarded during the period of customs custody and following the procedure which applies at ports of entry only approved government employees can have access to the material until after the entry has been cleared. Therefore labor, trained and controlled by the Division, will be necessary if the perishable, rare, and valuable plant material in the Bureau's care is to be handled without justifiable complaints from its owners.

Significance: To carry out the responsibility of preventing the entry of plant pests in accordance with regulations under the Plant Quarantine Act of 1912 and at the same time make provision for the receipt of plants which are highly desirable in the development of our horticulture and agriculture, provision has been made for the importation of plant material for propagation purposes under special permit. Since this provision became effective in 1919, material imported under special permit at ports in the eastern United States has been diverted to the District of Columbia for inspection and treatment if necessary. The Bureau has long recognized that the facilities available for handling such plants in the

District were entirely inadequate and did not provide the protection warranted. It was also recognized that much of this material had to be handled twice as it came to the country at ports like New York and then was shipped to the District for inspection prior to release. Consideration of these important facts finally resulted in providing funds for the construction of a modern plant quarantine inspection station at the port of New York in Hoboken, N. J. The providing of this station is a definite advancement in the effort to protect the country from the introduction of dangerous plant pests. To be effective, however, it is essential that facilities provided be so operated that the purpose for which they were intended be carried out.

For many years the Department has been importing natural enemies of certain introduced pests to aid in their control. In such importations it is essential that parasites that may prey on beneficial forms be eliminated. To do this material must be handled under quarantine conditions before it is turned over for release and colonization within the United States. In the past these quarantine conditions have been provided at certain laboratories of the Bureau where the material was propagated before liberation of colonies. These facilities while accomplishing their purpose were never fully satisfactory and in many cases the work had to be done under unusual difficulties. With the construction of the plant quarantine inspection station at Hoboken, provision was made for the construction of a modern plant setup where the natural enemies that were to be introduced could be handled under quarantine conditions which would permit the most effective handling of the various parasites and their development. The Hoboken building serves, therefore, a dual purpose, providing for the first time in history adequate facilities for safeguarding plant and parasite importations. The new building is a credit to our Government and represents pioneering in the field of protection of its vast horticultural and agricultural interests from introduced pests.

Plan of Work: The procedure possible with facilities provided by the modern inspection house at Hoboken has resulted in improved conditions for the importation of all plants imported in the eastern United States under special permit, other than those for the Department of Agriculture. Plant material so imported will be received for inspection at the new station at Hoboken where facilities are available for proper treatment, handling, and care so as to eliminate any pests that might occur on such plants. The inspections and handling of the plants which represent private property will be done by trained inspectors while still in the custody of the customs and before they have left the port of first arrival in the United States. All packages will be opened and inspected under quarantine conditions. Plants found to be infested or infected as well as those under suspicion will be treated by approved methods to assure their freedom from pests.

WORK UNDER THIS APPROPRIATION

General: This appropriation provides for administering various quarantines and regulatory orders to prevent the entry into the United States from foreign countries, Puerto Rico, and Hawaii of injurious insects and plant diseases by controlling and safeguarding the entry of plants and plant products. These activities include the enforcement of (1) foreign plant quarantines and regulatory orders issued under the Plant Quarantine Act of 1912, as amended; (2) rules and regulations governing the entry into the United States of railway cars and other vehicles, etc., from Mexico; (3) the Act of 1905 governing the importation of living insects into the United States; and (4) regulations governing the shipment of plants and plant products to the Mainland from Hawaii and Puerto Rico. The operations divide into two groups. One is concerned with authorizing the importation of plants and plant products which may enter the United States under the quarantines and regulatory orders. The other deals with inspections at ports of entry to detect and exclude dangerous plant pests and to see that plant material imported under permit meets the requirements to the authorization. The two projects are discussed as follows:

Project 1. Import and Permit Service for issuance of permits for the importation of plants and plant products to comply with plant quarantines.

Objective: To issue the permits necessary for the importation of plant material, the entry of which is restricted by the Plant Quarantine Act of 1912, as amended.

The Problem: The Act requires that permits be issued for importations of plant material regulated entry by the provisions of the quarantines promulgated pursuant to the Act. This requirement tends to regularize importations and facilitates prompt inspection by bringing each entry to the attention of inspectors. Connected with the purely routine clerical procedures of permit issuance, as such, are the identification of many plant diseases and insect pests found on foreign plant material actually brought to this country, and the indexing, filing, and analysis of the pest risk information accumulated through these interceptions, supplemented by a limited amount of similar information gleaned from world literature. This information is then utilized as a basis for decisions on requests for permits to make certain importations. Under this project it is necessary to conduct correspondence with the public regarding the foreign plant quarantines, their provisions for entry and permit issuance, draft instructions to the inspectors concerning specific importations, and to make a continual study of the quarantines themselves for the purpose of preparing information on the basis of which the quarantines and their supplemental regulations can be revised to meet the needs of continuously changing world conditions that directly affect the risk of introducing injurious insects and plant diseases into the United States.

Significance: Shipments of plant material brought to this country in advance of the issuance of permits for entry may involve considerable unanticipated expenditures with possible losses for the importer. If they consist of plant material prohibited entry on account of unusual pest risk he is faced with the alternative of abandoning the material for destruction or removing it from this country if conditions permit. In the meantime, the very plant pests which it is sought to exclude could have opportunity for escape. Such shipments may be highly restricted with respect to ports of entry, seasons during which importation is permitted, safeguarding treatments required as condition of entry, etc., which in turn may, and frequently do, involve delay in clearance and considerable added expense to the importer for movement to treating plants, etc. Without the preliminary considerations preceding permit issuance generally, the issuance of permits for the importations and the specific planning with importers and the inspectors at the ports of entry, the plant quarantine clearance of importations of plant material would be greatly impeded, more expensive for the importing public, and unless appropriations were greatly increased to provide for a vastly augmented force of inspectors, the protection given the country against the introduction of foreign insects and plant diseases would be very materially lessened.

Plan and Progress of the Work: Nearly all of this work is conducted from the Washington office. A small part is done in the ports, particularly in San Juan, Puerto Rico, and Honolulu, T. H., and this under direct supervision of the Washington office. Regardless of the fact that there has been a continuing increase in the issuance of permits during the past ten years, this project is operating with 10 less clerks than in 1930. Improved procedures, changes in regulations and restrictions, and the discontinuance of certain useful statistical records have made this possible. The number of permits, permit amendments, and permit cancellations issued during years ending March 31 are shown for comparison purposes:

	1938	1939	1940
No. permits issued:			
Limited...............	6,357	6,188	6,839
Valid until revoked...	700	758	526
No. permits amended........	not avail.	949	3,366
No. permits cancelled.....	not avail.	8,109	1,177
No. valid-until-revoked permits in force (approx.)	14,000	10,000	9,350

The estimated number of permits issued during 1930 is 2,600.

Project 2. Inspection at ports of entry of plants and plant products regulated by plant quarantines:

Objective: To protect and safeguard agriculture in the United States by preventing the introduction and establishment in, or the spread within, the United States of injurious insect pests and plant dis-

eases which exist in other countries and which may be carried by the plants and plant products of such other countries when offered for importation into the United States or which exist in the Territories of Hawaii and Puerto Rico and which may be carried by the plants and plant products of such Territories when moved to the Mainland of the United States.

The Problem: The problem involves the inspection of vessels, trains, and aircraft from foreign countries and their stores and passengers' and crews' quarters; passengers' baggage; freight, express, and mail; railway cars and vehicles from Mexico; articles carried by pedestrians from Mexico and Canada; supervision of the cleaning and the fumigation of railway cars from Mexico fouled with cottonseed; the erection of suitable sanitary safeguards to prevent the escape of injurious insects and plant diseases from infested or infected plant material offered for entry into the United States or temporarily within the confines of the United States pending exportation therefrom; the supervision of treatments required as a condition of entry for certain plant products; the inspection in the field, packing houses, and on the piers of plants and plant products of Hawaii and Puerto Rico to meet the certification requirements for their movement to the Mainland; the supervision of treatments authorized for certain fruits and vegetables to meet the certification requirements for movement from Hawaii and Puerto Rico to the Mainland; the inspection of passengers' baggage and mail prior to departure from Hawaii and Puerto Rico to the Mainland for plant material not permitted such movement on account of the pest risk incident thereto; the inspection and certification of plants and plant products imported for experimental or scientific purposes by the Department of Agriculture; the inspection of domestic plant material moving into the District of Columbia; the inspection and certification of domestic plant material leaving the District of Columbia to meet the pest protection requirements of the areas of destination; the inspection and certification of plants for distribution by the Department from Arlington Farm, Virginia, the Horticultural Field Station at Beltsville, Maryland, and the Plant Distributing Station at Glenn Dale, Maryland; arranging for the cooperative examination and certification of plants distributed from the Department's field stations at Savannah, Georgia; Coconut Grove, Florida; Chico, California; and Mandan, North Dakota; the operation, care, and upkeep of the Plant Inspection House at Hoboken, New Jersey, at which point, as well as at San Francisco, California; Seattle, Washington; San Juan, Puerto Rico; and Honolulu, T. H., an intensive inspection is made of plant propagating materials imported under special permit, during the period of which proper care must be given to this generally rare and valuable material which is entirely private property.

Significance: It is significant that $2,376,184 or nearly half of the Bureau's regular appropriation for the fiscal year 1941 is devoted to the eradication, control or the prevention of spread of certain introduced insects and plant diseases. This does not

include the cost of research on these pests and many others where no attempt is being made to eradicate, control, or prevent their spread. Nor is this figure indicative of the vast amounts paid by the public in State or private eradication efforts and in direct losses resulting from the ravages of introduced plant pests. It has been estimated that there are approximately 20,000 insects, not to mention plant diseases, with harmful capacities which have not as yet become established in the United States. The cost of keeping pests out of the United States is insignificant as compared to the cost of fighting them once they become established. Similarly there are important plant pests in Hawaii and Puerto Rico which must be prevented from becoming established on the Mainland for the same reasons as those discussed with respect to foreign pests generally.

Plan and Progress of Work: The work is organized in such a manner that the inspectors are stationed at most of the principal ports of entry in order that, with the cooperation of the Customs, vessels and aircraft from foreign countries may be inspected as well as all shipments from foreign countries containing plant material subject to restriction under the Plant Quarantine Act made available for inspection. Likewise through the cooperation of the Treasury and Post Office Departments foreign mail packages containing or supposed to contain plant material are made available for inspection at strategic points. At certain ports and in some instances at considerable distances from the ports of entry, commercial facilities are used, under the supervision of inspectors, for the application of fumigants, thermal treatments, or other sanitary safeguards prescribed as conditions of entry for specified plant products.

Along the Mexican Border, with the permission of Mexican officials, inspections are made in the Mexican railroad yards of freight cars for contamination with cottonseed, and if found to be so contaminated supervision is given to their cleaning prior to their crossing the Border for fumigation by the Bureau in the United States. Large freight shipments of fruits and vegetables from Mexico may be similarly inspected for the same purpose and for general quarantine purposes on the Mexican side of the border. Vehicles and pedestrians crossing both the Mexican and Canadian Borders are inspected in cooperation with the Customs to prevent the entry of prohibited or unauthorized plant materials.

On the Canadian Border, owing to the lack of sufficient inspectors, most of the quarantine work in connection with vehicular and pedestrian crossings is conducted through the cooperation of the Customs Service, with plant quarantine inspectors largely engaged in the inspection of foreign freight and express from and via Canada and in making frequent contacts with the Customs Service along the border to discuss plant quarantine problems as they arise.

In addition to the regular supervision of importations of plants and plant products into the Territories of Hawaii and Puerto Rico there are staffs engaged in the inspection, treatment, and certi-

fication of products of these islands which are subject to plant quarantine restriction, for movement to the Mainland.

Owing to the unusual risk of introducing injurious insects and plant diseases with rare and exotic plant propagating materials, provision has been made for the entry of most kinds of this material under special permit at specified ports of entry only, where intensive examination may be made by especially trained inspectors and where unusual facilities exist for the proper care and handling of this material (which is always the property of private individuals) and for the application of any necessary sanitary safeguarding treatments.

Mention has already been made of the cooperation of the Bureau of Customs of the Treasury Department and of the Post Office Department in this work. Mention is also made of the fact that important cooperative arrangements, partially financed under this project, exist whereby the State inspection services of Florida, California, and the Territorial plant quarantine services of Hawaii and Puerto Rico perform the majority of the maritime work in their respective States and Territories under direct supervision of, and with some assistance from Federal inspectors.

While the general nature of the work remains the same year after year there are variations due to both natural and unusual variations in foreign commerce. Lack of sufficient funds since the inception of the project in 1913 has made impossible the employment of sufficient inspectors to give the type of protection desired and no progress has recently been made through added personnel. However, some progress is made steadily through increases in the training and efficiency of the inspectors, the development of new inspection techniques by the inspectors for specific commodities, and the development of new safeguarding sanitary treatment procedures. Very marked progress was made during the year 1940 by the erection at Hoboken, N. J., of modern quarters for the inspection of plant material imported under special permit. As has been previously indicated, this building has up-to-date facilities not only for the inspection and treatment of the plants but also for their care during the period they are in the Bureau's custody for plant quarantine purposes.

The following table indicates the volume of work performed under this project:

Activities of the Division of Foreign Plant Quarantines 1938-1940

	1938	1939	1940
No. ships inspected	32,450	30,244	30,172
Airplanes inspected................	4,262	4,969	5,279
Foreign mail parcels inspected.....	252,523	467,718	362,883
Cargo inspected (lots).............	41,485	39,951	42,481
No. vehicles inspected (Mexican Border)...............	3,876,192	4,019,169	4,965,260
No. pieces baggage inspected (Mexican Border)..................	336,695	340,487	562,113
Interceptions prohibited and restricted plant material............	76,341	72,078	75,048
Freight cars inspected (Mexican Border).............	37,677	35,512	36,475
Freight cars fumigated (Mexican Border)..............	9,953	4,024	4,131
Shipments moving from Hawaii to Mainland inspected and certified.	1,918	2,721	3,200
Pounds of fruits and vegetables treated in Hawaii................	None	97,483	214,306
Shipments from Puerto Rico to Mainland inspected and certified.....	2,221	2,812	2,670

Revenues: A fee of $4 is charged for each railway car fumigated on the Mexican Border, the proceeds therefrom being covered into the Treasury as miscellaneous receipts. During 1940, $16,608 was collected in fees. As the demands of commerce will influence this activity it is impossible to make an estimate as to the future revenues from this source, although it is not anticipated that the figure will be materially less in 1941 and 1942.

(z) CERTIFICATION OF EXPORTS

Appropriation Act, 1941	$31,862
Budget Estimate, 1942	31,862

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)
Certification of exports	$31,700	$31,862	$31,862
Unobligated balance	162	---	---
Total appropriation	31,862	31,862	31,862

WORK UNDER THIS APPROPRIATION

General. The work under this appropriation is concerned with the inspection and certification for export of plants and plant products to meet the sanitary requirements of the foreign countries to which they are exported, as follows:

Certification for export of plants and plant products to meet sanitary requirements of foreign countries:

Objective: To facilitate exportations of plants and plant products by inspecting and certifying them, with respect to insect pests and plant diseases, as required by foreign countries as a condition of importation into such countries, without which the importations are usually prohibited.

The Problem and its Significance: In recent years many foreign countries have been increasingly aware of the pest risk accompanying importations of plants and plant products and have increased their enforcement of existing sanitary requirements or promulgated and enforced more stringent requirements. The American exporters have faced loss of markets without strict inspection and accurate certification of their exports of plant material. Under the provision which has been made annually in the appropriation acts for the Department, commencing in 1927, this activity has enabled the exporters to meet these requirements and save their markets if the condition of the material warranted the required certification.

Plan and Progress of the Work: This work is performed largely in conjunction with Port Inspection activities under the appropriation for Foreign Plant Quarantines, in view of the fact that export certificates may be issued from any of the various ports where plant quarantine inspectors are stationed. The annual volume at ports such as New York, N. Y., Seattle, Wash., Portland, Ore., San Francisco, and San Pedro, Calif., is large, and at other ports it is relatively small. Consequently inspectors are paid entirely from this appropriation at only a few ports, and all plant quarantine inspectors may be called upon to participate, with reciprocal assistance on port inspection work from inspectors under this project during slack periods of export

certification. Two field supervisors, one in the East and the other in the West, spend considerable time in the field contacting the representatives of the Agricultural Marketing Service and of State agencies who cooperate by making the shipping point sanitary inspections of certain fruits for export certification in conjunction with grade and quality inspections under other legislation.

The following tabulation for the years shown indicates the volume of this work:

	1938	1939	1940
No. of certificates issued.....	9,208	9,412	5,298
No. of containers..............	4,017,807	3,591,165	1,410,096
No. of different commodities...	67	65	68
No. of countries of destination	72	83	74
No. of ports of export.........	33	37	30

The current European War obviously affected the volume of these certifications for 1940, as applied to fruits, but it is anticipated that, as new markets are found, or as old markets are restored, the work will again assume its former proportions. In fact there are indications that this readjustment is already taking place.

Revenues: A fee of $1.00 is charged for each certificate issued, the proceeds therefrom being covered into the Treasury as miscellaneous receipts. It is anticipated that approximately $5,000 will be collected in fees in 1941.

(aa) CONTROL OF EMERGENCY OUTBREAKS OF INSECT PESTS AND PLANT DISEASES

During the fiscal years 1940 and 1941 appropriations aggregating $3,300,000 were made available as follows:

First Deficiency Act, 1940, approved April 6, 1940.......	$2,500,000
Second Deficiency Act, 1940, approved June 27, 1940......	800,000
	3,300,000

Of the amount available, $1,590,100 was obligated during the fiscal year 1940, leaving a balance of $1,709,900 available for obligation during the fiscal year 1941.

The Budget for 1942 includes no request for an appropriation under this item. It is expected, however, that an estimate of funds required to carry out the purpose of the authorizing legislation for the season of 1941 will be submitted for consideration in connection with a deficiency appropriation act. It is generally recognized that information that may be

assembled regarding the status of plant pests which may occur in emergency outbreaks, such as grasshoppers, Mormon circkets, chinch bugs, etc., during the season when they are active gives a reasonably satisfactory basis on which an estimate of funds may be made. Such information is not available until late in the fall and considerably after the time when regular estimates are prepared. It is also recognized that plans and operations for the control of incipient and emergency outbreaks of plant pests have to be made and carried out on the basis of crop rather than fiscal years. For effective work, funds that are provided should, therefore, be available early in the calendar year.

WORK UNDER THIS APPROPRIATION

Work under this appropriation is conducted on the basis of a crop season rather than a fiscal year. It is therefore not practicable to report on the work done under this item on the basis of a fiscal year. The following briefly summarizes the activities which have been conducted with funds made available under the authorization for the control of incipient and emergency outbreaks of plant pests. None of the appropriations made under this authorization have been carried in regular Acts providing funds for the Department. The language providing some of these appropriations has required that special reports be prepared and submitted to Congress. One such report was submitted in January, 1938, and another in January, 1939.

Public Resolution No. 20, 75th Congress, authorized an appropriation of $2,000,000 for the control of incipient and emergency outbreaks of insect pests and plant diseases, including grasshoppers, Mormon crickets, and chinch bugs. It also authorized that the funds appropriated should remain available until expended and the appropriation of such additional sums as might be necessary to replenish the fund to its original amount at the beginning of each fiscal year.

Public Resolution No. 91 (75th Congress) amended this legislation by removing the limitation of $2,000,000 and authorizing the appropriation of such amounts as might be necessary. Eight appropriations have been made under these authorizations, as follows: Two of $1,000,000 each, the first by Public Resolution No. 26, approved April 27, 1937, and the second by Public Resolution No. 55, approved July 17, 1937; one of $2,000,000 by Public Resolution No. 81, approved March 2, 1938; one of $700,000 by the Second Deficiency Act, fiscal year, 1938; one of $3,000,000 by the First Deficiency Act, fiscal year 1939; one of $1,750,000 by Public Resolution No. 22, approved June 13, 1939; one of $2,500,000 by the First Deficiency Act, fiscal year 1940; and one of $800,000 by the Second Deficiency Act for the same year. Of these appropriations all but the last two have expired; these two remain available until June 30, 1941.

The great part of the funds provided by these appropriations have been used to enable the Department to cooperate with States in combating a widespread outbreak of grasshoppers. The funds have, however, made it possible to take active measures against a newly established pest, the white-fringed beetle. During the early months of 1937 and again in 1938,

army worms appeared in outbreak numbers in certain States. These pests can be controlled in much the same manner as the grasshoppers by the application of poisoned bait. A small amount from the appropriations was used for the purchase and transportation of bait materials distributed to and used by cooperating States to combat army worms. During 1937 an allotment was also made to combat outbreaks of Mormon crickets in North Dakota and South Dakota. This was the first time that the latter pest had occurred in outbreak numbers in these two States. Work on control of Mormon crickets was then under way in other States financed from allotments from emergency funds provided for relief. The period during which effective work could be done on Mormon crickets was short and the funds allotted from the emergency relief appropriation were not available for work in North and South Dakota. A small amount was also allocated for work to control Mormon crickets in States where the control work had not been provided for by allotments from Emergency Funds. In the season of 1938 allotments were made for Mormon cricket control work in the Intermountain States. Work against this insect has continued.

In July, 1937, an incipient outbreak of the white-fringed beetle was outlined in limited parts of Alabama and Florida. This insect is a native of South America and was not previously known to occur in the United States. It attacks a wide variety of crops and has demonstrated that it is a potential pest of major importance over a wide area. It has since been found in other regions in these States, and in Mississippi and Louisiana, and allotments of funds for its control have been made from this appropriation.

During the 1940 field season, control activities were also carried on against the pear psylla, the chinch bug, the legume weevil, and the mole cricket.

SUPPLEMENTAL FUNDS

(Complete bureau statement)

Direct Allotments

Projects	Obligated, 1940	Estimated Obligations, 1941	Estimated Obligations, 1942
Special Research Fund, Department of Agriculture:			
Digestion by leaf eating insects	$ 8,218	$ 8,000	$ 4,800
Effect of artificial control practices on natural enemies of insect pests	16,950	16,500	14,700
Total, Special Research Fund	25,168	24,500	19,500
Allotment: Regular Item for White Pine Blister Rust Control:			
Planning, coordination, and technical direction of blister rust control	288,940	390,000	390,000
Blister rust quarantine enforcement	9,845	10,000	10,000
Cooperative control of blister rust on State and private forests	- - -	- - -	100,000
Total, White Pine Blister Rust Control	298,785	400,000	500,000
Emergency Relief Appropriation Acts:			
Locating and destroying Thurberia cotton plants	59,180	- - -	- - -
Barberry eradication	880,311	441,509	- - -
Eradication of the Dutch elm disease	2,018,367	966,482	- - -
White-pine blister rust control	1,311,506	746,996	- - -
Control and prevention of spread of gypsy moth	731,095	405,000	- - -
Peach mosaic control	140,499	83,800	- - -
Phony peach disease control	199,390	93,624	- - -
Citrus canker eradication	62,887	43,860	- - -
Wild cotton eradication	50,281	42,564	- - -
Construction of a plant and parasite receiving station at Hoboken, N. J.	13,733	(a) 1,167	- - -
General administrative expenses	203,226	103,408	- - -
Total, Emergency Relief Appropriation Acts	5,670,475	2,928,410	- - -
Total, Supplemental Funds (direct allotments)	$5,994,428	$3,352,910	$519,500

(a) Carried over from allotment under 1939 Act.

PASSENGER-CARRYING VEHICLES

The authorization for purchase of passenger-carrying vehicles for the fiscal year 1942 shows a decrease of $4,300, from $40,900 in 1941 to $36,600 in 1942. However, this is only an apparent decrease, since the authorization for 1941 included $6,325 for purchase of cars under the blister-rust control item, which item is transferred in the 1942 estimates to a new appropriation title. On the basis of a revised 1941 authorization of $34,575, the authorization of $36,600 for 1942 represents an increase of $2,025.

It is estimated that the $36,600 mentioned above will provide for the replacement of 62 cars, turning in 62 old cars in exchange. Therefore, there will be no increase in the number of cars.

Of the cars to be turned in, 41 are of 1937 or earlier model. The average mileage of the machines to be turned in was in excess of 38,000 miles on August 1, 1940, and of course additional mileage will be added before the cars are actually exchanged.

WHITE PINE BLISTER RUST CONTROL

This is a new appropriation item, which presents under one heading funds for the control and prevention of spread of white-pine blister rust. Funds for this work have heretofore been included under other appropriations, from which they are eliminated in the present estimates and consolidated under this new heading. The appropriation is based on legislation approved April 26, 1940 (Public 486, 76th Congress, Chapter 159, Third Session, 54 Stat. 168, 169), which provides for forest protection against white-pine blister rust and describes principles, limitations and procedures for carrying out work directed toward this object. While this legislation does not specifically direct that all the funds appropriated to the Federal Government for the control of white-pine blister rust be included under a single appropriation, in the interest of simplicity, it is believed that the grouping of such funds under a consolidated item will permit and assure uniform consideration of Federal appropriations to protect the public interest in white pine forests from this important introduced disease.

The activities carried out by the Federal Government to control the white-pine blister rust are conducted by two different Federal departments and by various agencies within each of these. The Bureau of Entomology and Plant Quarantine of the Department of Agriculture is responsible for the over-all planning, coordination, technical advice, pine and disease surveys, enforcement of the blister-rust quarantine, and cooperative work on State and privately-owned lands not intermingled with those Federally-owned. The Forest Service of the Department of Agriculture is responsible for the operations carried out on lands under its jurisdiction. The Department of the Interior is responsible for operations carried out on lands under its jurisdiction, including national parks, Indian reservations, and Oregon and California revested lands.

The language proposed for this new item provides that the funds appropriated thereunder shall be consolidated under one head and at the same time clearly indicates the responsibilities of the various agencies engaged in this work. The activities of the various agencies are explained in more detail below.

WHITE PINE BLISTER RUST CONTROL

Appropriation Act, 1941:	
Transferred in 1942 Estimates from:	
Bureau of Entomology and Plant Quarantine, "Blister rust control"	$400,000
Forest Service, "National forest protection and management"	644,000
Total available, 1941	1,044,000
Budget Estimate, 1942	1,409,000
Increase	365,000

PROJECT STATEMENT

Projects	1940	1941 (Estimated)	1942 (Estimated)	Increase
1. Planning, coordination, and technical direction of blister rust control (Bureau of Entomology and Plant Quarantine) ..	$288,940	$390,000	$390,000	- - -
2. Blister rust quarantine enforcement (Bureau of Entomology and Plant Quarantine)	9,845	10,000	10,000	- - -
3. Blister rust control operations on the National Forests (Forest Service)	693,000	644,000	694,000	+ $50,000(1)
4. Blister rust control operations on lands under jurisdiction of Interior Department	- - -	- - -	215,000	+ 215,000(2)
5. Cooperative control of blister rust on State and private forests (Bureau of Entomology and Plant Quarantine) ..	- - -	- - -	100,000	+ 100,000(3)
Unobligated balance	1,215	- - -	- - -	- - -
Total appropriation .	993,000	1,044,000	1,409,000	+ 365,000

INCREASES

The increase of $365,000 in this item for 1942 consists of:

(1) An increase of $50,000 is requested for Ribes eradication on national forests and adjacent lands endangering national forests. This will make funds for this purpose available in the same amount as for the fiscal year 1940.

Objective: To control white-pine blister rust by the initial eradication of Ribes (currant and gooseberry) on national forest lands when such control work is necessary to protect white pines; to follow up initial control work with second or subsequent workings needed to remove Ribes which have come in since initial treatment.

The Problem: The imported white-pine blister rust -- which kills native American species of white pines -- has spread to most sections of the country where white pines are of commercial importance. In the western white pine region (the Inland Empire) and in the sugar pine region (California and southern Oregon) this disease is a very serious threat to the continued productivity of the national forests.

The Bureau of Entomology and Plant Quarantine has developed measures for the control of the disease, and is responsible for control in State and private timberlands. The program of control on the National Forests is thoroughly integrated with that of the Bureau of Entomology and Plant Quarantine. In fact, field operations of the two agencies are closely cooperative.

Control is effected by eradicating Ribes bushes within and adjacent to white-pine stands. Most of the work is done by hand-pulling the bushes, although chemical and mechanical eradication is possible in some situations. Camps must be maintained for the large number of laborers required for this work, much of which is done in steep, rugged, inaccessible areas.

In the eastern and central States most of the control work in the national forests is being carried out by the Civilian Conservation Corps, but in the West the problem extends into wide areas which the CCC cannot reach. It is planned to utilize the CCC and relief agencies to the utmost possible extent, but relief labor in these thinly populated areas is too scarce to do the job in time. The rapid spread of infection in Idaho, and from Oregon into California, necessitates a type of program which these relief agencies cannot provide, if the areas not yet initially worked are to be protected.

Significance: Western white pine is the most valuable component of the of the mixed timber stands in the Inland Empire (eastern Washington, northern Idaho, and western Montana), and the same statement applies to sugar pine in its natural range in California and Oregon. Both regions are highly important as sources of commercial timber supplies for the Nation. The lumber industry is the backbone of local economy

in the Inland Empire States and in the timbered regions of California and Oregon. Without the highly valuable western white and sugar pines, commercial timber operations (and therefore employment of thousands of woods workers) would be economically impossible on the present scale. The national forests, operated to supply a sustained yield of timber, must be protected from this imported disease in order to safeguard present and potential timber supplies and labor-providing potentialities.

In the national forests of the Inland Empire blister-rust control, under way since 1931, will have resulted in the extension of initial Ribes eradication to about 1,000,000 acres by the end of the fiscal year 1941, leaving unworked some 374,000 acres of western white pine lands within the control zone. In the sugar pine region only about 375,000 acres of national forest land will have been worked for the first time by the end of the fiscal year 1941, leaving untouched 889,000 acres of the total of 1,264,000. The disease is becoming more widespread each year on unprotected areas, and cumulatively increasing damage may be expected. One working is not enough, since additional Ribes plants seed in following eradication. Additional later eradication treatments must be made on parts of the control areas at intervals to insure control.

Plan of Work: Blister-rust control measures developed by the Bureau of Entomology and Plant Quarantine are used by the Forest Service on the national forests. Close contact is maintained with the Bureau in planning and accomplishing the national-forest program. The work consists of (1) surveying and mapping the areas where control work is necessary because of the occurrence of Ribes species in and near stands of susceptible white pines on areas of such site quality and accessibility that control work is justified because of present or future timber values, (2) systematic elimination of all Ribes plants within and adjacent to (usually within 900 feet of) control areas, (3) checking the results to make sure that adequate control has been accomplished, and (4) reexaminations followed by repeat eradication of Ribes where needed. Thus, by eliminating the alternate host, the disease can be effectually controlled.

The currant and gooseberry bushes are pulled by laborers working in organized crews. Most of the remaining work is in rugged mountainous country, relatively inaccessible. Laborers must be housed in camps. It is proposed under this increase to establish two additional camps, of 33 men each, in the Inland Empire region and one additional camp in California. CCC and labor financed from Emergency Relief Appropriation Act funds is used also to the maximum practicable extent. Hours of labor, travel restrictions, and remoteness of the projects from centers of population make it impossible to accomplish all the needed work by the use of emergency funds.

Financial requirements: About 70 percent of the requested increase will be used for wages and subsistence of temporary laborers. Tools, equipment, and salary and expense of a limited number of permanent employees will also be required. This itemization follows:

Permanent personnel, field:

2 P-1 Junior Foresters	$4,000	
2 CAF-4 clerks	3,600	
Subtotal, permanent personnel		$7,600
Temporary labor		35,480
Supplies and materials	$4,600	
Communication service	150	
Travel	900	
Transportation of things	280	
Equipment	990	
Subtotal, other		6,920
Total increase requested		$50,000

Of this increase about $30,000 is expected to be allotted during the fiscal year 1942 to the Inland Empire region of Idaho, eastern Washington, and Montana for the initial protection or reworking of some 7,000 acres which could not otherwise be reached in the Kaniksu, Coeur d'Alene, St. Joe, Clearwater, Kootenai, and Cabinet National Forests; and about $20,000 to cover some 5,000 acres in the sugar-pine region of Oregon and California, largely for use in the Sierra, Stanislaus, Eldorado, Plumas, Lassen, Klamath, and Siskiyou National Forests.

The rate of spread of blister rust into the unprotected parts of the national forests named above makes the situation in these western regions especially pressing. It is expected that the amounts proposed will continue to be supplemented by substantial allotments from emergency relief appropriation acts. Forest Service expenditures from emergency relief funds during the calendar year 1939 amounted to approximately $101,000 in the Inland Empire region and $132,000 in the sugar-pine region. Blister rust surveys show that, to prevent heavy losses, initial eradication ought to be finished within the next two or three years on those western white pine forest areas of the Inland Empire which bear young stands. In California infection has been found established at several points in the northern part of the State. Initial work throughout the Sierra Nevada region should therefore be finished within about six years if the sugar-pine stands are to be protected before infection causes heavy losses.

(2) <u>An increase of $215,000 is requested for blister rust control operations on lands under the jurisdiction of the Department of the Interior, as follows</u>:

(a) <u>An increase of $155,000 is requested to protect white pine stands in the national parks of the United States</u>.

<u>Objective</u>: To carry out operations for the control of white-pine blister rust on national parks to protect trees which have esthetic or recreational value.

The Problem and Its Significance: Blister rust kills white pine in areas where Ribes are growing among or near the trees. These trees are highly valuable and important for recreational and esthetic purposes on national parks. The rust is effectively controlled by eradicating the Ribes within a few hundred feet of the trees. These bushes must be destroyed before the disease kills the trees and destroys the esthetic and recreational value of many areas in the national parks.

The national parks are established on areas of surpassing esthetic and recreational value. The maintenance of the forest cover is essential for the protection of such values. In certain national parks, such as Acadia, white pines constitute the principal coniferous trees and the parks would take on a relatively barren appearance in winter time if it were not for the evergreen foliage provided by the white pines. In other parks, individual white pine stands occur in very conspicuous and strategic locations, and disfigurement by a forest tree disease would be disastrous to the appearance of the park. In other areas, such as Crater Lake and Sequoia National Parks in Oregon and California, the white and sugar pines provide a background for spectacular features of the park. A great deal of the estimated recreational value of these parks would be lost without the white pine setting. Ribes eradication is essential for the protection of these white pine areas from blister rust infection, which would not only result in killing the trees but during the process would badly disfigure them with cankers and dead branches and could ruin the areas for park purposes.

During the past 6 years the National Park Service has received no regular or emergency funds for white pine blister rust control and has been compelled to limit such work to that which could be accomplished with CCC labor, which in some instances has been far from meeting the needs. One of the greatest threats to western park forests right now is from the spread of the white pine blister rust into California, with the danger of losing our magnificent sugar pine and other susceptible white pine species in Yosemite, Kings Canyon, and Sequoia National Parks unless adequate funds can be provided to prevent the spread of the disease to these pines through the eradication of the Ribes species (currants and gooseberries) which constitute the alternate host for this rust disease. Work of this nature is now under way on a small scale through the use of CCC, but the job is so immense that the accomplishment of the available CCC labor forms but a small part of the program which must be accomplished in order to afford adequate protection to the important sugar pine and white pine stands of these magnificent parks.

Plan of Work: This estimate provides for work on some of the areas in the national parks that CCC camps cannot reach. The number of camps has been reduced in recent years, and for that reason certain areas worked initially by CCC camps cannot provide for the areas needing rework in that manner. The rework designated below is needed in areas in which the original population of currant and gooseberry plants has been destroyed but in which there has been some sprouting from roots and regeneration from dormant seed in the soil. About 50 percent of forest areas need to be reworked once or twice after the initial Ribes eradication job is completed.

Proposed Regular Fund Blister Rust Control Program for the National Park Service, 1942-1950. - White pine blister rust control was initiated in the National Park system with small regular appropriations in 1929 at Acadia National Park and in 1930 at Mount Rainier National Park. With the spread of the disease southward both in the East and in the West, more areas have been either directly affected or threatened, until now practically all park areas having forests of 5-needle pines require early control work to protect these important trees.

From 1929 to 1932 small regular appropriations were used for blister rust control, but during the past 6 years no regular or emergency funds have been allotted to the National Park Service for tree disease control. The work has been limited to that which could be accomplished with CCC labor. In many instances this has fallen far short of meeting the needs for early control. Restrictions on the use of the CCC, inaccessibility, and the magnitude of the program make necessary a material expansion.

A careful study has been made of national park areas bearing white pines in order to hold the control areas to the minimum on which the pines are of outstanding scenic, scientific, or recreational value. Areas have been excluded from control plans where the pines were of little importance or where the trees would soon be replaced by equally valuable vegetation. The area included in the control program is the minimum area that is considered adequate to preserve important white pine values. The Government has recently spent millions of dollars to acquire white and sugar pine areas to add to the already considerable areas of fine white pines within the parks.

The attached tabulation of the proposed program by years and by areas includes both initial control and re-eradication of the Ribes. The control area involved is 326,463 acres. Initial eradication has been completed through June 30, 1940, on 130,038 acres. Re-eradication is needed on most of this area. It is estimated that an initial appropriation of $155,000 for 1942 and similar appropriations for a number of subsequent years would enable the Service to complete protection of the parks, involving 196,425 acres of remaining initial work, 232,089 acres of second working, and 182,597 acres of a final third coverage.

UNITED STATES
DEPARTMENT OF THE INTERIOR
National Park Service
Washington

White Pine Blister Rust Control Proposed Program

Area	Total acres needing control	Acres worked through June 30, 1941 (initial control)	Total acres of work remaining		
			Initial eradication	Second working	Third working
1	2	3	4	5	6
Acadia National Park, Maine	20,668	20,668	–	11,261	20,668
Blue Ridge Parkway, Va., N.C.	–	–	–	–	–
Great Smoky Mts. N.P., Tenn., NC .	20,000	17,000	3,000	20,000	10,000
Shenandoah National Park, Va.	26,000	26,000	–	20,000	10,000
Crater Lake National Park, Oregon.	2,795	1,145	1,650	474	700
**Glacier National Park, Mont.	* 4,250	2,150	2,100	4,150	4,200
**Kings Canyon Nat'l. Park, Calif. ..	8,320	2,560	5,760	6,240	4,680
Lassen Volcanic Nat'l. Park, Calif.	11,660	11,660	–	8,745	6,559
**Sequoia National Park, Calif.	71,280	4,656	66,624	53,460	40,095
**Yosemite National Park, Calif. ...	131,336	35,945	95,391	91,759	73,877
Mount Rainier Nat'l. Park, Wash. .	8,254	8,254	–	7,700	8,100
Rocky Mountain Nat'l. Park, Colo. .	7,000	–	7,000	2,000	500
Grand Teton National Park, Wyo. ..	2,000	–	2,000	1,000	600
**Yellowstone National Park, Wyo. ..	12,900	–	12,900	5,300	2,600
Total	326,463	130,038	196,425	232,089	182,579

* Not yet surveyed: estimate beyond 1942 uncertain

** Parks for which estimates are submitted for 1942.

Financial Requirements:

The 1942 estimate of $155,000 is divided as follows:

Yellowstone National Park, Wyo.	$10,000
Glacier National Park, Mont.	20,000
Kings Canyon National Park, Calif. ..	15,000
Sequoia National Park, Calif.	35,000
Yosemite National Park, Calif.	75,000
Total	155,000

The above estimates by areas were arrived at by consultation between representatives of the National Park Service and representatives of the Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in the field. The status or plan of the work on each of the above parks is given below:

Yellowstone National Park - $10,000: Although no blister rust infection has been found in Yellowstone National Park, an infection has been discovered in the Gallatin National Forest 19 miles from the northwest corner of the park. This estimate is to provide for supervision and labor to begin the eradication of Ribes in the following areas:

	acres
Mammoth	1,140
Mt. Washburn ...	4,000
Sylvan Pass	2,600
Craig Pass	4,000
Firehole Lake ..	600
Other	560
Total	12,900

It is expected that the proposed appropriation for 1942 and similar amounts thereafter will complete the initial eradication of Ribes in all areas in the Yellowstone National Park now recommended for such treatment by the Division of Plant Disease Control and that it will provide for a second and third working where needed.

Glacier National Park - $20,000: Initial eradication of Ribes in the white pine stands of Glacier National Park has been started with the use of CCC labor. The present estimate is for the purpose of completing in 1942 initial eradication on the areas mapped thus far and for starting the re-eradication of sprouts and seedlings on the tracts covered in 1939.

Kings Canyon National Park - $15,000: Initial eradication of Ribes in Kings Canyon National Park has been started. This estimate is to provide supervision and labor for 4-1/2 months with the hope of nearly completing initial eradication over 2,500 acres in the General Grant Section of the park. The remaining white pine acreage in the newly acquired sections of the park will not be started until some subsequent season and in the absence of a survey no estimate for that work is made at this time.

Sequoia National Park - $35,000: Initial eradication has been started in Sequoia National Park with CCC labor, but inability to obtain sufficient CCC camps, and also inability to locate such camps where needed in connection with Ribes eradication, makes it imperative that these funds be provided. This estimate is to provide two blister rust camps for about 4 months to complete, if possible, one-sixth of the 6 year program recommended by the Division of Plant Disease Control. There are 71,280 acres of 5-needled pines at Sequoia which require protection.

Yosemite National Park - $75,000: Initial eradication has been started with CCC labor in the Yosemite National Park. This estimate assumes that the CCC program will continue and that the amount indicated is therefore simply supplemental to the CCC program. It is planned to eradicate Ribes on 25,000 acres annually, of which this estimate will assume 20,000 acres annually and the CCC 5,000 acres annually. This estimate is to provide funds for 124 supervisory and labor personnel for a 4-1/2 months' period. Initial eradication ought to be completed by 1946. At least 131,336 acres of 5-needled pines require protection at Yosemite.

A summary of proposed expenditures, by objects, under this increase of $155,000 follows:

Summary, by Objects, of Proposed
Expenditures for Blister Rust Control on the National Parks
under the Increase requested for 1942

Personal services, field
Permanent:
P-2, Assistant Forester (1 at $2600) $2600

Total permanent	$2,600
Temporary labor	120,000
Total, personal services, field	122,600
Supplies and materials	12,473
Communication service	35
Travel	627
Transportation of things	295
Rents	2,200
Equipment	16,770
Total, other obligations	32,400
Grand total, National Park Service	155,000

(b) An increase of $60,000 is requested to protect the white pine forests of the Oregon and California revested lands from white pine blister rust.

Objective: To carry on Ribes eradication operations to protect white pine stands on the Oregon and California revested lands from white pine blister rust.

The Problem and its Significance: There are approximately 113,786 acres under the jurisdiction of the Oregon and California Revested Lands Administration on which five needle pines occur. The total volume of these pines is about 1,126,000,000 feet, board measure, of which about four-fifths is sugar pine and the remainder western white pine. The value represented in this timber is such that, unless funds can be provided to prevent the blister rust from reaching the pines, a serious loss may follow.

Plan of Work: The estimate of $60,000 for 1942 will provide a permanent assistant forester in the administrative headquarters to supervise the work and coordinate it with similar work being done by other agencies on adjoining areas, and, in addition, temporary personnel for supervising the work in the field, including general supervisor, camp foremen, clerk, cooks, and warehouse man for four 33-man camps or their equivalent. Inasmuch as the work will have to be carried on from camps, funds are required for camp construction, equipment, and maintenance. Automotive equipment will be essential for the transportation of men and materials, and this equipment, in turn, will require the employment of truck drivers and mechanics.

Financial requirements: No control work has so far been undertaken by the Administration, although 23,674 acres of O. & C. lands had by the beginning of 1940 been covered on the Ribes eradication program by the Bureau of Entomology and Plant Quarantine under emergency allotment. In order to protect the O. & C. pine adequately, it is estimated that it will be necessary, in completing the initial work and in carrying out the needed second and third workings, to cover 260,550 acres, and that the total funds needed to complete the task will amount to $775,695. It is proposed that this volume of work be spread over a period of years.

A summary of proposed expenditures, by objects, under this increase of $60,000 follows:

Summary, by Objects, of Proposed Expenditures for
Blister Rust Control on the Oregon & California Revested Lands
under the Increase requested for 1942

Personal Services, field	
Permanent	
P-2 Assistant forester, 1 at $2600 ...	$2,600
CAF-4 Clerk, 6 months at $1800	900
CAF-1 Junior clerk, 6 months at $1260	630
Temporary labor	42,870
Total personal services	47,000
Supplies and materials	6,000
Communication service	100
Travel	1,500
Rents...................................	200
Photographic and stenographic duplicating	200
Equipment	5,000
Total, other obligations	13,000
Grand total, O. & C. Lands	60,000

(3) An increase of $100,000 is requested for the cooperative control of blister rust on State and private forests (Bureau of Entomology and Plant Quarantine).

This total increase will be divided by projects, as follows:

(a) An increase of $50,000 is requested for cooperative Ribes eradication on State and private lands and lands endangering public lands in the sugar pine region of California and Oregon and the western white pine region of Idaho, Washington, and Montana.

Objective: To carry on cooperative Ribes eradication to control blister rust on State and private lands and lands endangering public lands in the sugar pine forests of California and Oregon and the western white pine forests of Idaho, Washington, and Montana, and to progress at a rate sufficiently rapid to prevent major losses to young growth and merchantable timber.

The Problems and its Significance: The general public has a vital interest in the maintenance of healthy and productive forests on private and State lands as well as those on Federal property. The Federal interest is due to the fact that some of the private and State lands are intermingled with Federally owned forests, and infections developing on them are likely to menace Federal property, as well as to the further fact that the maintenance of productive forests is of great economic value to the community and to the Nation. Public law No. 486 of the 76th Congress adopts a policy under which the Secretary of Agriculture is authorized and directed to use blister rust control appropriations on "all forest lands irrespective of ownership thereof, when in the judgment of the Secretary of Agriculture the use of such funds on such lands is necessary in the control of the white pine blister rust." Congress has thus established a policy under which cooperation in the maintenance of blister rust control on private as well as publicly owned lands is a Federal responsibility. This law also requires cooperation from State and local public authorities and from individuals with respect to work on private and State lands except those so intermingled as to threaten public property.

There are about 1,150,000 acres of privately owned white and sugar pine in the West which have not yet been reached on initial Ribes eradication. To meet this cooperative provision, $30,200 in cooperative appropriations and contributed services is available in the western region for the fiscal year 1941, and we have been notified by the State Foresters of California and Idaho that recommendations for increases of $50,000 and $36,000, respectively, in the two States will be pending before the next legislatures. In all, the cooperative appropriations and contributions available in this region for 1941 are expected to be $116,200. The estimate for this work project contemplates a Federal appropriation in order partially to meet the Federal obligations under the cooperative clause of Public 486, 76th Congress.

Plan of Work: The appropriation proposed is expected to be used for the expenses of about three camps of 33 men each on the State and privately owned property in the western region. These camps will be placed in areas covered by cooperative contributions and where public interest is involved owing to the desirability of maintaining the forests in an economically productive condition. Additional camps are expected to be maintained by the cooperative contributions from State and private agencies, and such contributions may further be used for facilitating services such as aiding in the transportation of supplies and personnel for the Federal camps.

This estimate is intended to cover only the Federal share of work in privately owned areas isolated from Federal property and therefore not coming under the provision of the Lea Act, which exempts from the cooperative contribution requirement those lands adjoining and intermingled with the Federal property in such a way that the presence of blister rust or Ribes on them would threaten infection in Federally owned property.

It is necessary that the work on these intermingled private and State lands proceed along with the national-forest operations, but no estimate is made for them at this time, with the expectation that enough relief labor will be obtainable in the areas concerned so that this work on intermingled privately owned lands can be handled under allotments from Emergency Relief Appropriation Acts. The expenditures by the Bureau of Entomology and Plant Quarantine from such emergency relief allotments during the calendar year 1939 amounted to $359,828 in the western white pine region of Idaho, eastern Washington, and Montana, and to $335,698 in the sugar pine region of California and Oregon. These areas are already suffering severe losses from blister rust in certain sections, mainly in Idaho, and initial Ribes eradication should be completed as rapidly as possible in both the western white pine and the sugar pine regions. Thereafter initial Ribes eradication will be required only with respect to tracts where mature timber is out and where the lumbering operations result in a new group of young pines and of Ribes seedlings developing simultaneously.

Financial Requirements: The future financial requirements under this work project will be largely dependent on the availability of State and local appropriations and private contributions in the western region.

(b) An increase of $50,000 is requested for Ribes eradication on State and private lands and lands endangering public forests in the Northeastern and Lake States and in the Southern Appalachian region.

Objective: To protect young stands of white pine from blister rust by Ribes eradication on State and private lands in the East in cooperation with the public and private agencies concerned.

The Problem: Regular Federal blister rust control appropriations in the past have been sufficient only to provide for leadership in blister rust control operations, pine disease surveys, method improvement, quarantine

enforcement, and similar functions, and have not included any amount for the labor of Ribes eradication in State and private forests. Under Public No. 486 of the 76th Congress, Federal responsibility for assisting in work on private lands is set up and provisions are made for requiring cooperative contributions from State and local authorities and individuals and organizations concerned as a condition for the use of Federal funds on such private and State property. There are available during the fiscal year 1941 State and private contributions to this cooperative project in the eastern United States amounting to $201,396. The present estimate of $50,000 is a conservative amount, which will enable the Bureau partially to meet cooperative contributions from State and private owners in the Eastern States.

Significance: There are some 24,340,000 acres of control area in the Eastern States on which pine of sufficient value to justify protection is present. By the beginning of 1940, 18,474,000 acres have been initially protected and about 4,900,000 have been reworked for the removal of sprouts and seedlings subsequent to initial protection. There thus remain over 5,870,000 acres of control area needing initial eradication work and even larger forest areas which should be re-examined for the removal of sprouts and seedlings. Nearly all (95 percent) of this unworked acreage in the East is in State or private ownership.

Plan of Work: The expenditures under this project will be primarily for labor in the destruction of Ribes on property covered by cooperative contributions from State, local authorities, and private owners. About 6 supervisors will be needed to assure that the work is carried out efficiently and in areas that have a sufficient public interest to justify Federal cooperation. The laborers employed under this allotment will work with those employed under the cooperative contributions and in crews of 5 unskilled to each crew leader. It is expected that this project will provide for about 400 man-months of labor paid by the Federal Government and that the 6 supervisors will direct not only the Federal laborers but those paid under cooperative contributions also.

Financial Requirements: Future appropriations under this project will be dependent on the extent of public and private appropriations and contributions to the cooperative control work. In addition to this regular and cooperative work, it is anticipated that allotments from relief appropriation acts may be available for Ribes eradication on State and privately owned lands so situated that the public has an interest in maintaining their productivity from the standpoint of employment and industry. During the calendar year 1939, blister rust control expenditures by the Bureau of Entomology and Plant Quarantine from relief allotments totaled $979,690 in the Eastern States, almost all of which was used on State and private land. It is planned to use the 1942 funds partly for the employment of supervisors in the professional and subprofessional grades, but primarily for laborers engaged in Ribes eradication on lands being worked in direct cooperation with the owners and State and local authorities.

The following summary shows the breakdown of the increase of $100,000 requested for 1942 under this entire financial project:

Personal services, field:	
Permanent:	
P-2 Assistant forester, 4 at $2600	$10,400
SP-5 Field assistants, 2 at $1800	3,600
Total permanent	14,000
Temporary	77,000
Total, personal services	91,000
Supplies and materials	2,500
Travel	1,500
Equipment	5,000
Total, other obligations	9,000
Grand total	100,000

WORK UNDER THIS APPROPRIATION

General: This appropriation provides for forest protection against the white pine blister rust in the United States on lands in public and private ownership in accordance with the provisions of Public 486, approved April 26, 1940. White pine lands needing protection from blister rust occur on the national forests, national parks, Oregon and California revested lands, the public domain, State forests, and privately owned forests. The national-forest lands are administered by the Forest Service of the Department of Agriculture; the national parks, revested lands, public domain, and Indian reservations by the Department of the Interior; the State forests by the various State forestry agencies; and private forests by their respective owners. The funds needed for work on these lands have been coordinated and combined into one consolidated estimate. The work is conducted under the technical leadership of the Bureau of Entomology and Plant Quarantine. Funds are provided this Bureau for planning, coordination, and technical direction of blister rust control operations throughout the United States, for blister rust quarantine enforcement, and for cooperative control work on State and private lands. From the standpoint of Federal interest, State and private lands may be classified as (1) those intermingled with and adjoining Federally owned forests and (2) lands isolated from public forests but involving a public interest because of their economic value to communities and the Nation. Cooperation is required by Public 486 where such lands are not intermingled with those that are Federally-owned.

The white pines constitute a renewable forest resource of great importance to present and future forestry in this country. These forests are in serious danger from white pine blister rust, a destructive fungous disease of foreign origin that is now present in 25 States. The rust kills the white pines, the young trees dying quickly - the older trees more slowly. Blister rust has demonstrated its ability to kill not only individual white pines but whole stands. It is an alternate-host fungous disease which spends part of its life cycle on currants or gooseberries. Spores produced on these plants infect white pines, where cankers are

formed which eventually kill the tree. Control is effected by elimination of the currants and gooseberries (Ribes spp.) within and near the white pine areas to be protected. In unprotected areas the disease is killing the young growth, and many of the older trees scattered through the forests are gradually succombing to the disease. There are some 30,000,000 acres of control area in the United States, and Ribes have been destroyed on about 21,000,000 acres. The work under this appropriation is to provide for the continuous supply of white pine timber needed to promote the stability of white pine forest-using industries, employment, and communities by preventing the spread to, and eliminating the blister rust from, all productive white pine forest lands, irrespective of their ownership.

Objective: To prevent white-pine blister rust from damaging the 5-leafed pine forests of the country either through killing the present stand or by attacking the younger reproduction in the white pine areas and preventing the development of the white pine forests of the future.

The Problem: There are in the United States about 15 million acres of valuable 5-leafed pine forests, susceptible to blister rust attack, extending from Maine southward to Georgia and westward to Minnesota, as well as in the Pacific Coast and Rocky Mountain States. In order to prevent blister rust infection, it is necessary to destroy the Ribes within these stands and the surrounding border zone of several hundred feet around the stands. The white pine forests and the border zone together approximate 30 million acres, including lands in both public and private ownership. Of this, 21,112,818 acres had been covered under initial protection by January 1, 1940, and 5,378,416 acres had been worked the second time. Somewhat more than one billion Ribes have been destroyed, and the number of man days of effective labor have amounted to 5,811,567.

In the eastern United States at the beginning of the present (1940) field season about 5,870,000 acres of control area still need to be worked initially. Such initial work is also needed on some 870,000 acres of western white pine in Idaho, eastern Washington, and western Montana, and 1,950,000 acres of sugar pine in California and Oregon.

Significance: The blister rust control problem, while an immediate emergency from the standpoint of infection, is primarily concerned with the forest conditions of 20, 50, 100 years or more from now. Blister rust develops especially rapidly on young pine trees and destroys them in a much shorter time than it kills the mature trees. By protecting the young reproduction and second-growth pine in the pine-growing areas, we are providing for the forests of the future.

The stumpage value of the mature white-pine timber is estimated at about $400,000,000. This, however, represents only a small proportion of the actual values involved, for the forests of the future, if adequately protected against blister rust, fire, insect pests, and other plant diseases, have a potential capacity for yielding about $40,000,000 worth of timber per year, mill value, over the next century or crop rotation. This value is in addition to the continued economic and commercial

importance of the white pine produced in the Northeastern States, the Lake States, and the Southern Appalachian region, where the local residents in rural areas find that their woodlots provide a continuous source of income. In the Northeastern States the third crop of pine is now being cut since the country was first settled, and in the Southern Appalachian States white pine is increasing in importance since the chestnuts were eliminated by chestnut blight some years ago.

Western white pine is the most important timber species in the Inland Empire (western Montana, northern Idaho, and eastern Washington). The blister rust is firmly established here and, unless it is controlled, it threatens to wipe out the lumber industry, which furnishes 63,000 man-months work annually. Logging and manufacturing of lumber is one of the chief industries of the region, and western white pine represents about 75 per cent of the forest products shipped from and consumed within the region. In the sugar pine region of California and southern Oregon the situation is much the same. Sugar pine, very susceptible to the disease, is the most valuable component of mixed coniferous stands. Control of the disease, now present, is essential to continued production of sugar pine.

Plan and Progress of the Work. Ribes eradication for the protection of white pine stands against blister rust involves several operations:

1. Pre-eradication surveys and maps are made to determine the boundaries of the pine stands and to note whether currant and gooseberry plants are present throughout the stand and, if not, to locate the sections in which they exist in dangerous numbers. Only areas of such site quality and accessibility that control work is justified because of present or future timber values are considered for protection. There were mapped in this manner 2,711,745 acres in the blister rust control program in 1939.

2. Ribes eradication is carried out by crews systematically working those parts of the forest in which Ribes are present. The Ribes themselves are destroyed either by hand-pulling or by the use of chemicals or by mechanical equipment, depending on the size of the Ribes and the nature of the topography. In 1939, 82,311,851 Ribes were so destroyed on 1,863,203 acres, of which 1,157,112 represented initial work and the remainder re-eradication. The results are carefully and promptly checked to make sure that adequate control has been accomplished, and reexaminations are made at intervals of several years, followed by repeat eradication of Ribes where needed.

The usual method of control is hand-pulling the Ribes plants, although spraying and various methods of mechanical elimination are used in some cases. In the rugged, inaccessible country of the West, camps are necessary for housing labor crews. CCC labor and crews employed under Emergency relief funds have been used extensively, but it is not practicable to work this class of labor on much of the inaccessible area remaining to be worked because of administrative

difficulties and the shortage of relief labor in thinly populated areas. The costs of initial treatments are averaging about $1 per acre in the East and about $5.50 or more per acre in the West. The cost of a second working of the same areas several years later is usually much less per acre, and the acreage needing rework is much smaller than that covered on the initial eradication.

3. Disease surveys are carried out during appropriate seasons of the year to determine the spread of the blister rust. Forests can be protected against blister rust regardless of the presence of the disease in the locality, but priority of work is determined partially on the degree to which infection is threatening in each area. Blister-rust surveys are also being made continuously in areas from which currant and gooseberry plants have been removed in past years to be sure that the eradication work is also carried out with a degree of completeness sufficient to protect the stands.

4. As soon as the eradication crews complete a pine stand, the resulting control area is given a systematic check to be sure that the men have maintained the proper degree of efficiency and have not missed Ribes that would be likely to cause damage by continuing to spread blister rust to white pine.

5. White-pine nursery stock is protected by the eradication of Ribes around the nurseries. During 1939, 93 nurseries containing 87,000,000 white pines were covered for this purpose. Most of this pine nursery stock is produced in Federal Forest Service nurseries and a large part of the remainder in State-owned nurseries.

6. The eradication of the cultivated black currant is a special problem because of the fact that it is highly susceptible to blister rust and is an introduced plant found almost entirely in gardens and residence areas. Its eradication throughout white pine regions is a necessary step in establishing control of the disease. During 1939 this work resulted in the removal of 11,352 cultivated black currants from 2,154 locations.

7. Work is continuously being carried on for the purpose of developing and improving chemical, mechanical, and hand methods for the eradication of Ribes. New sprays, soil drenches, and hand and power tools are developed each season for the purpose of improving the rapidity and effeciency of the work and reducing costs.

The projects into which the blister rust control program is divided and the objective of each are as follows:

Project 1. Planning, Coordination and Technical Direction of Blister Rust Control throughout the United States. (Bureau of Entomology and Plant Quarantine):

Objective: To conduct pre-eradication surveys of pine areas and blister rust distribution; to plan and coordinate blister rust control operations on lands of whatever ownership; to supervise and check on the

efficiency of blister rust control; to develop improved methods of eradication; and to conduct educational measures concerning the best methods for carrying out, and the need for, blister rust control work. In general, employees are paid under this project if their time is devoted to blister rust control on lands of more than one classification of ownership, such as both Federal and private.

Project 2. Blister Rust Quarantine Enforcement. (Bureau of Entomology and Plant Quarantine):

Objective: To prevent the introduction and spread of blister rust into uninfected and lightly infected areas and to prevent the importation and interstate transportation of blister rust host plants into areas in which blister rust control measures have been or are expected to be carried out. Under this project, arrangements are made, in cooperation with interested State and Federal agencies for the issuance of permits required by Federal and State quarantines to nurseries which desire to ship Ribes into white-pine growing States and the refusal of such permits with respect to proposed shipments into blister rust control areas.

Project 3. Blister Rust Control Operations in the National Forests (Forest Service):

Objective: To protect the valuable white pine stands and white pine reproduction areas of the national forests against blister rust by means of the eradication of Ribes within and for a border zone around such stands, and to carry out the direct field administration of control operations on the national forests, including the final decision as to where and how such operations are to be conducted; the obtaining of transportation, compensation, and direct supervision of the necessary personnel; the providing of supplies and equipment, and the detailed inventory of Ribes and susceptible pines on the land as a basis for planning the actual field work. The determination as to which stands are of sufficient value, either from the standpoint of production of timber, watershed protection, or on account of the esthetic and recreational value, to justify the expense of blister rust control, the proposed location of camps, and the routine day-to-day checking on the efficiency of the crews are carried out by the Forest Service and the Bureau of Entomology and Plant Quarantine in cooperation and consultation.

Project 4. Blister Rust Control Operations on Lands under jurisdiction of the Interior Department:

The activities under this project are conducted by separate units of the Interior Department. The following discussion of the work is therefore described in several sections, divided according to the organization carrying on the work.

(a) Blister Rust Control Operations in the National Parks.

Objective: To protect white pine from blister rust in those sections of the national parks in which 5-leafed pine trees have such esthetic or

recreational values as to justify the expense of blister rust control; also to carry out the direct field administration of control operations and the obtaining of transportation, compensation, and direct supervision of the necessary personnel for the protection of such stands.

Determination as to which areas in the national parks contain sufficient white pine to justify the expense of blister rust control, and questions as to the location of camps and the routine day-to-day checking of efficiency, are matters of cooperation and consultation between the National Park Service and the Bureau of Entomology and Plant Quarantine. This project is carried out by the National Park Service of the Department of the Interior.

The amounts obligated and estimated for future obligations are as follows:

	1940	1941	1942
Blister Rust Control Operations in the National Parks	--	--	$155,000

(b) Blister Rust Control Operations on the Oregon and California Revested Lands:

Objective: To protect the white pine stands of the O & C revested lands from white pine blister rust by means of Ribes eradication within the stands and by establishing a border zone around them.

Determination as to which areas in the public domain and the O. & C. revested lands contain sufficient white pine to justify the expense of blister rust control and questions as to the location of camps and the routine day-to-day checking of efficiency are matters of cooperation and consultation between the O. & C. Revested Lands Administration of the Department of the Interior and agencies of interest in the Department of Agriculture. This project is carried out by the O. & C. Revested Lands Administration, Interior Department.

The amounts obligated and estimated for future obligations are as follows:

	1940	1941	1942
Blister Rust Control on Oregon and California Revested Lands	--	--	$60,000

Project 5. Cooperative Control of Blister Rust on State and Private Forests. (Bureau of Entomology and Plant Quarantine):

Objective: To cooperate with the States and other interested agencies in protecting State-owned and privately-owned forests against white pine blister rust. From the standpoint of Federal interest such lands may be classified as (1) those intermingled with and adjoining Federally-owned forests, and (2) lands isolated from public property but involving

a public interest on account of their economic value to the community and to the Nation. Cooperation with States and individuals is required under Public Law No. 486, 76th Congress, with respect to the second of those two classifications, that is, where such lands are not "intermingled with those that are Federally-owned." Cooperative contributions from State and private sources for 1942 are estimated at $317,592. This work is carried out by the Bureau of Entomology and Plant Quarantine in cooperation with the forest officials and others interested in the States concerned.

Control operations on State and private forests are divided into two work projects. Owing to the limited number of relief workers available in the lightly populated forest regions, and the existence of certain parts of the areas in which relief laborers are not adaptable to the particular kind of operations needed, provision is made in the estimate for partially matching cooperative State and private contributions.

The amounts obligated and estimated for future obligations are as follows:

	1940	1941	1942
Cooperative control of blister rust on State and private forests, Western program	--	--	$50,000
Cooperative control of blister rust on State and private forests, Eastern program	--	--	50,000
Total			100,000

SUPPLEMENTAL FUNDS

Direct Allotments

Projects	Obligated, 1940	Estimated obligations, 1941	Estimated obligations, 1942
Emergency Relief Appropriation Act of 1938:			
For control of white pine blister rust:			
Bureau of Entomology and Plant Quarantine	(a) $1,311,506	(a) $746,996	- -
Forest Service (includes obligations for blister rust control from emergency relief funds for work on the national forests)	(b) 234,000	(b) 90,000	- -
Total, Emergency Relief Appropriation Act of 1938	1,545,506	836,996	- -

(a) Also shown under "Bureau of Entomology and Plant Quarantine."

(b) Entire allotment of emergency relief funds for work on the national forests shown under "Forest Service."

Note:--Civilian Conservation Corps labor has been used wherever practicable on lands of all classes of ownership and has been the main force of work on national parks and Indian lands.

PASSENGER-CARRYING VEHICLES

The proposed expenditures for the purchase, maintenance, repair, and operation of motor-propelled and horse-drawn passenger-carrying vehicles for the fiscal year ending June 30, 1942, will in gross amount to $14,780, less estimated allowances of $1,130 on old cars to be exchanged, or a net amount of $13,650. Of the net amount of $13,650, $8,650 will be expended by the Bureau of Entomology and Plant Quarantine, of the Department of Agriculture, and $5,000 by the Department of the Interior. The Forest Service of the Department of Agriculture will purchase no passenger-carrying cars.

It is estimated that the net amount of $13,650, aforementioned, will provide for the purchase of 22 cars, 15 by the Department of Agriculture (Bureau of Entomology and Plant Quarantine), and 7 by the Department of the

Interior. The Department of Agriculture will exchange 15 old cars on its purchase of 15 new cars. The Department of the Interior will exchange no old cars on its purchase of 7 new cars.

All of the old cars to be turned in by the Department of Agriculture are of 1938 or earlier model. The average mileage of the machines to be turned in was in excess of 65,000 miles on August 1, 1940, and, of course, additional mileage will be used before the cars are actually exchanged.

The 15 replacements to be purchased by the Department of Agriculture will be used by agents and supervisors in White Pine Blister Rust Control throughout the white pine growing regions of the United States. The cars will be used from Malone, N. Y.; Harrisburg, Pa., (2); Boston, Mass., (2); Montpelier, Vt., Spokane, Wash., Richmond, Va., Medford, Oreg., Oakland, Calif., Escanaba, Mich., Newaygo, Mich., Stevens Point, Wis., Walker, Minn., and Milwaukee, Wis.

Of the 7 new cars to be purchased by the Department of the Interior, 2 will be used by supervisors of White Pine Blister Rust Control, 1 in the National Parks of California, and 1 in the Revested lands in Oregon, and 5 station wagons will be used for the transportation of laborers.